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HELMINTHOSPORIUM DISEASE OF RICE. III. BREEDING RESISTANT VARIETIES—SELECTION OF RESISTANT VARIETIES FROM GENETIC STOCK

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Helminthosporiose, caused by *Cochliobolus miyabeanus* (Ito *et* Kurib.) Drechsler *ex* Dastur (*Helminthosporium oryzae* Breda de Haan), is one of the major diseases of rice in India, causing serious loss in yield when it breaks out in an epiphytotic form (Padmanabhan *et. al.*, 1948). Such epiphytotics occur under conditions favourable for the development and spread of infection through air-borne conidia. Though protective fungicidal spraying has been reported to be successful in reducing air-borne infection, growing resistant varieties would be the most economical method of checking the loss caused by the disease.

Work on breeding for resistance to Helminthosporium disease has been in progress at the Central Rice Research Institute, Cuttack, since 1947. The procedures employed in testing the resistance of rice varieties, viz., bringing about artificial infection, scoring the infection and evaluation of resistance of the varieties, together with the results obtained in the first phase of the programme completed in 1955, are presented in this communication.

Material and Methods. Five hundred and thirty eight improved strains of cultivated rice, which have been released for cultivation from different states in India and some foreign countries, were taken up for testing against the disease. These varieties were of different durations, ranging from 80 to 205 days, and suitable for different climatic and agronomic conditions. Most of them were primary selections, while some were hybrid strains. The reaction of these varieties to Helminthosporium disease was not known previously.

For isolation of resistant varieties a primary series of three screening tests were carried out under artificial infection at the seedling stage, in which the more susceptible types were rapidly eliminated. When the screening tests were in progress, the reaction of all the 538 test varieties was also observed under natural infection at all stages of growth in type maintenance plots. Only those varieties which were comparatively resistant under artificial infection in the screening tests and under natural infection in the type maintenance plots were included in the final series of tests under artificial infection at the seedling and flowering stages in the field.

A. *Artificial infection tests in the seedling stage in pot culture.*

(i) RAISING SEEDLINGS: A unit of 50 seedlings for each variety was raised in small pots of 6 inches diameter at 10 seedlings per pot. The pots contained normal well-sieved field soil to which a sufficient quantity of well-rotten farm yard manure had been added.

(ii) ISOLATE USED FOR INOCULATION: A single spore isolate of *Helminthosporium oryzae* Breda de Haan obtained at Cuttack (Culture No. 135 A, Central Rice Research Institute) was used for inoculation. As no evidence regarding the existence of specialization in pathogenicity could be obtained from preliminary infection tests with isolates from Uttar Pradesh, Orissa and Madras (Padmanabhan, 1953), the artificial infection tests were carried out with one isolate throughout.

(iii) PREPARATION OF INOCULUM: *Helminthosporium oryzae* was found to produce very few spores in artificial culture. Attempts were made to get sufficient spores for inoculation by cultivating the pathogen on twelve natural and artificial media, under different temperature ranges, viz., 18–22 °C, 23–26 °C, 29–33 C and 33-38 °C, in alternate light and shade, in partially dessicated condition, and by exposing cultures to high humidity and mechanical injury. Sporulation was not abundant in any of the treatments, at any rate not sufficient for a programme of testing a large number of seedlings. In the absence of sufficient spores for artificial infection, a mixture of mycelial powder and spores was used as the inoculum, since it was known that mycelium was also infective (Sherf *et. al.*, 1947). The method of preparation of the inoculum was, however, a modification of the one suggested by Sherf *et. al.*, (*l.c.*).

Fifteen gms. of unhusked rice were taken in 250 ml. Erlenmeyer flasks, soaked in 10 ml. of water and sterilized for half an hour at 20 lbs. pressure. The flasks were inoculated with the fungus and incubated at 18–20 °C for 21 days, when profuse mycelial growth and a small amount of spores were produced. The contents of the flask were then emptied on to an open dish, air dried, powdered in a pestle and mortar and sieved through a fine mesh. This dry powder was used as the inoculum.

(vi) METHOD OF INOCULATION: The seedlings were artificially infected when they were about 4 weeks old and were in the 4th to 6th leaf stage. They were sprayed with water from a pressure retaining knapsack sprayer and fine droplets of water were deposited on the leaves. The dry powdered inoculum was taken in a 500 c.c. Erlenmeyer flask with a piece of finely perforated butter paper tied over its mouth. By inverting and gently tapping the flask a cloud of inoculum was released, which settled down uniformly on the moistened leaves. Thirty gms. of inoculum was used for a block of 1,500 seedlings. Inoculations were carried out after dusk during the months of August and September and the inoculated seedlings were kept enclosed for 36 hours in a humid chamber made of wet cloth suspended from an overhead bamboo frame The average temperature within the humid chamber was between 25 to 27.5 C during the period of incubation. To ensure high humidity inside the moist chamber about 2 inches of water was maintained on the floor by raising a mud bund all round the pots.

(v) METHOD OF SCORING INFECTION: Observations on the development of infection were taken usually 7–10 days after inoculation. In each plant, the leaf which showed the maximum infection was scored. The first sign of infection appeared nearly 16 hours after inoculation in some varieties, when minute light-brown or brownish-red spots of the size of a pin point could be distinguished. In some cases the spots ceased to grow further. In other cases, the leaf spots developed in size and became dark brown in colour. Thus two types of leaf spots, undeveloped and developed, were clearly distinguishable at the end of a week.

On the bases of the number and stage of development of the spots observed 7–10 days after infection, the following score chart (Fig. 1) was prepared and observations were recorded with reference to the score chart.

Score 1 = 1–3 undeveloped spots.
" 2 = 4–15 undeveloped spots,
" 3 = above 15 undeveloped spots.
" 4 = 1–3 developed spots.
" 5 = 4–15 developed spots.
" 6 = above 15 developed spots.

When both undeveloped and developed spots were present in a leaf, the highest score that could be given with respect to any of the classes of infection was given for the particular leaf.

(vi) EVALUATION OF RESISTANCE: The infection score for a variety was arrived at by averaging the scores obtained by all infected plants of the variety. Selection for resistance was based upon an average infection score of not more than '3' with not more than 10 per cent of the plants receiving the score '4'. Varieties with score '5' or above in any of the test plants were screened out.

B. *Artificial infection tests in the seedling and flowering stages in the field.*

Artificial infection tests in the seedling and flowering stages were carried out in the field with the varieties carried forward from the screening tests. As the varieties were of different durations, susceptible varieties of similar durations were included for comparison.

When the seedlings were one month old, half the seedlings of each bed were uprooted and used for transplanting. The remaining seedlings in each bed were artificially infected following the procedure outlined earlier for pot-grown seedlings. Observations were taken on disease incidence on the seedlings seven days after inoculation.

The layout of the transplanted field was a simple randomised block with four replications, varieties in each duration group being planted together. There were three rows of each test variety of 10 feet, separated from one another by a row of the susceptible variety. Artificial infection

Fig. 1. Varietal susceptibility to *Helminthosporium oryzae* Breda de Haan—Chart showing grades of infection and their corresponding scores (1-6).

was carried out at the flowering stage of each group of varieties. The humid chambers used in the field were made of movable wooden frames covered with detachable cloth curtains. Observations were taken a week or ten days after artificial infection. For each variety, fifteen random plants in each block were observed and scored with reference to the standard chart.

The varieties which emerged as resistant in the test were subjected to a second test on the above lines in the following season.

RESULTS. Out of the 538 varieties included in the present study, 518 were screened out as susceptible on the basis of their reaction under artificial infection in the screening tests and under natural infection in the field. Only 20 varieties were, therefore, included for field inoculation at the flowering stage.

Six varieties, Ch. 13, Ch. 45, T. 141, Co. 20, T. 498-2A, and BAM.10 emerged as resistant on the basis of their reaction in the field inoculation tests in the seedling and flowering stages. These six varieties were subjected to a second field inoculation in the next season in which their resistant character was confirmed.

The chief characters of the resistant varieties have been reported earlier (Padmanabhan and Ganguly, 1953). A list of the varieties tested and their reaction to Helminthosporium disease are presented in Table I.

DISCUSSION. In the present investigation, artificial infection at the seedling stage was adopted for screening out the more susceptible types, but the final selection for resistance was based upon the reaction of the varieties in the seedling as well as flowering stages. It was necessary to test the reaction of the varieties at flowering stage also, because rice plant becomes progressively more susceptible to Helminthosporium disease with increase in age and is most susceptible during the flowering and grain forming stages (Padmanabhan and Ganguly, 1954).

Besides the changes accompanying maturity, nutritional deficiencies principally of K and N, the ratio of Fe/Mn in the leaves,the presence of free H_2S in the root zone etc. also predispose rice to infection by *H. oryzae*. Therefore in carrying out the relative susceptibility tests on the seedling as well as in later stages, care was exercised to raise the test plants in a healthy condition. Seedlings were grown in well-sieved field soil with a basal dose of farm yard manure. In the fields also the crop received adequate fertilization.

In bringing about artificial infection, spore-cum-mycelial dust was used in place of spore suspension. Sherf *et. al.* (1947) have shown that mycelial dust, though slightly less efficient than spore suspension, is also capable of producing infection. Spore-cum-mycelial dust was preferred in the present investigation as few spores were produced by the fungus in culture media. On the other hand, sufficient quantity of spore-cum-mycelial dust could be prepared in paddy media for inoculating a large

TABLE. I. Reaction of rice varieties to Helminthosporium disease (tested at Central Rice Research Institute, Cuttack).

Place of origin of varieties.	Resistant	Moderately susceptible.	Susceptible.
INDIA			
1. Andhra			AKP. 1 (Bobbiliganti), AKP. 2 (Sunkisannam), AKP. 3 (Gunpursannam), AKP. 4 (Maharajabhogam), AKP. 5 (Mypali), AKP. 6 (Mypali), AKP. 7 (Palgarabayyahunda), AKP. 8. (Maharajbhogam), AKP. 9 (Bangarutheega), AKP. 10 (Bangarutheega), AKP. 11 (Ramasagaram).
			HS. 1, HS. 8, HS. 12, HS. 19, HS. 21, HS. 22, HS. 35, HS. 38, HS. 39, HS. 47.
		MTU. 12 (Pedha Atragada)	MTU. 1 (Akkulu), MTU. 2 (Akkulu), MTU. 3 (Basangi), MTU. 4 (Basangi), MTU. 5 (Krishnakatukulu), MTU. 6 (Atragada), MTU. 7. (Guttikusuma), MTU. 8 (Vankisannam), MTU. 9 (Garikasannavari), MTU. 10 (Krishnakatukulu), MTU. 11 (Konamani), MTU. 13 (Delhibhogam), MTU. 14 (Agragada), MTU. 15, MTU. 16, MTU. 18 (Kodijillama), MTU. 19.
			SLO. 1 (Punasakonamani), SLO. 2 (Punasakonamani), SLO. 3 (Konamani), SLO. 4 (Konamani), SLO. 5 (Palagummasari), SLO. 6 (Punasaakkulu), SLO. 8 (Sannabasangi), SLO. 9 (Gortibasangi), SLO. 10 (Ratnachudi), SLO. 11 (Bikirisannam), SLO. 12, SLO. 13 (Punasaakkulu), SLO. 14 (Punasaakkulu), SLO. 17, SLO. 18.
2. Assam.			AR. 1 (Salibadal), AR. 108–1 (Dholabadal), AR. 353–148, AS. 2 (Kasalath) AS. 3 (Basmati), AS. 20–1 (Garen), AS. 35 (Farmah), AS. 46 (Ausjaria, AS. 48 (Dubaichanga), AS. 88, C. 203–3 (Chengri), D. 138–6 (Tepidumai) D. 204–1 (Dumai), HBJ. 1, NBJ. 2, HBJ, 3, HBJ, 4, M. 36–30 (Baurashmurali), M. 142 (Koimurali), M. 175–1 (Dholajali), S. 22 (Latisali), S. 55 (Badshabhog), S. 115 (Latamaguri), S. 126 (Laundumra), SB. 279 (Gamiribora), SC. 54–60 (Vijoysali), SC. 94–47 (Kerrsali), SC. 412–56, SC. 308–51 (Andrewsali), SJ. 226 (Bengalijoha), SL. 70a (Ahomsali), T. 2089 (Prasadbhog), T. 2090 (Andrewsali) T. 2019 (Badshabhog), T. 2092 (Laundumra), T. 2094 (Jahari), T. 2095 (Latamaguri), T. 2096 (Gomiribora), T. 2097 (Karanganj), T. 2100 (Latisali, T. 2102 (Kerrsali), T. 2104 (Kasalath).

3. Bihar.	T. 498–2A.		BHR. 16 (Motisal), BHR. 36 (Kessore), BHR. 88 (Dahia), BHR. 115 (Dahia), BHR 141 (Jhulansar), BHR. 76–BK.
4. Bombay.		Mugad–81.	Ambemohar–59, Ambemohar–157, Ambemohar–159, Antrasal–67, Antarsal–90, Antarsal–200, Bhadas–79, Chimansal–94, Dodgya–622, Fine Waksal, Halga red–224, Halga White–1690, Jaddu–1061, Kamod–86, Kolamba–42, Kolamba–184, Kolamba–540, Kolpi–70, Krishnasal–10, Luchai, Maskaty–1315, Mugad–81 Mugad–141, Mugad–161, Mugad–249, Panvel–61, Patnai–6, P.R. 90, Waksal–207, Warangal–57, Warangal–487, Yalkirisal–4, Zinya–31, Zinya–149, 280–51–36.
5. Kashmir.			Bansal, Budgi, Mushka Budgi, Budgi x Baber, Begam, Lolanzan, Rati Basmati.
6. Kerala.			Chuvannamakkali, Chuvannavellai, Kochuvillu, Kuravalan, Veravadantan, Panamkoba, Kichidisamba, Arikiriayashi, Samba, Valshivanandan.
7. Madhya Pradesh.		C.P.16.	C.P.1, C.P. 2 (Nungi), C.P. 3 (Sultigurmatia), C.P.4 (Gurmatia), C.P.5 (Ludko), C.P.6 (Budhiabako), C.P.7 (Ajan), C.P.8. (Benisar), C.P.9 (Luchai). C.P. 10 (Chattri), C.P. 11 (Dubraj), C.P. 12 (Banspati), C.P.13 (Kurbimohar), C.P.14, (Badshabhog), C.P.15 (Chinoor), C.P.17, C.P.18, C.P.19.
8. Madras.			Adt. 1 (Red Sirumani), Adt. 2 (White Sirumani), Adt. 3 (Kuruvai), Adt. 4 (Kuruvai), ADT. 5 (Nellore Samba), Adt. 6 (Red Ottadan), Adt. 7 (White Ottadan), Adt. 8 (Molakolukulu x White Sirumani), Adt. 9 (Poonkar), Adt. 10 (Korangusamba), Adt. 11 (Nellore Samba), Adt. 12 (Chitrakali), Adt. 13 (Sannasamba), Adt. 14 (Vellaikar), Adt. 15 (Mutant from Adt. 4), Adt. 16 (Konakuruvai), Adt. 17 (Muthusamba), Adt. 18 (Vellai Kuruvai), Adt. 19 (Sarapalli), Adt. 20 (Hybrid, Adt. 3 x Adt. 2), Adt. 21 (Vadansamba), Adt. 22 (Vadansamba), Asd. 1 (Karsamba Red), Asd. 2 (Karsamba white), Asd. 3 (Veedhivadangan), Asd. 4 (Kuruvaikalyan), Asd. 5 (Karthigasamba), Asd. 6 (Anaikomban), Asd. 7 Kasmaba Red).
	Co. 20 (Tella) Sannavadlu)	Co. 6 (Sadaisamba, Co. 10 (Gobikar), Co. 23 (Rangoon Samba), Ptb. 4 (Vellari) Ptb. 10 (Thavalakannan), Ptb. 12 (Chitenni), Ptb. 18 (Eravapandy), Ptb. 21 (Thekkan).	Co. 1 (Natural cross from GEB. 24), Co. 2 (Poombalai), Co. 3 (Vellaisamba), Co. 4 (Anaikomban), Co. 5 (Chinnasamba), Co. 7 (Sadaisamba), Co. 8 (Anaikomban), Co. 9 (Karsamba Red), Co. 11 (Ayansamba), Co. 12 (Sendhinayagam), Co. 13 (Arupatham Kodai), Co. 14 (Co. 3 x Burma Variety), Co. 15 (GEB. 24 x Adt. 10), Co. 16 (Same as Co. 15), Co. 17 (Vadansamba), Co. 18 (Vellaikar), Co. 19 (Sirumani), Co. 21 (Arupathamsamba), Co. 22 (Manavari), GEB. 24 (Mutant in Konamani), Co. 25 (Hybrid), Co. 26 (Hybrid). Plr. 1 (Garudansamba), Plr. 2 (Chitrakali), Plr. 7. Ptb. 1 (Aryan), Ptb. 2 (Ponnaryan), Ptb. 3 (Eravapandy), Ptb. 5 (Velutharikayama), Ptb. 6 (Athikraya), Ptb. 7 (Parambuvattan), Ptb. 8 (Thavalakannan),

Table I (Contd.)

Place of origin of varieties	Resistant	Moderately susceptible.	Susceptible.
			Ptb. 9 (Same as Ptb. 8), Ptb. 11 (Halliga), Ptb. 13 (Kayama), Ptb. 14 (Maseathi), Ptb. 15 (Kavunginpoothala), Ptb. 16, Ptb. 17 (Jeddu Halliga), Ptb. 19 (Athikraya), Ptb. 20 (Chitenni).
9. Mysore.			B. 16 (Thogarina), B. 194 (Musali), B. 281 (Belikannanhegge), B. 805, B. 888, B. 1399 (Putta-Bhatta), H. 324, H. 419, H. 535, S. 54, S. 67, S. 139 (Mysore Kaddi), S. 199 (Alur Sanna), S. 246 (Nagpur sanna), S. 317 (Halubbalu), S. 328, S. 476, S. 547, S. 590, S. 624 (Maharajabhogam), S. 661 (Coimbatore sanna), S. 699 (Coimbatore Sanna), S. 701 (Coimbatore Sanna), S. 749 (Rathanchoodi).
10. Orissa.	BAM. 10 (Mypali). T. 141 (Seru-Chinnamali).		BAM. 1 (Boroponke), Bam. 2 (Boroponke), Bam. 3 (Bayyahunda), Bam. 4 (Bayyahunda), Bam. 5 (Ratnachudi), Bam. 6 (Ratnachudi), Bam. 7 (Navakotisannam), Bam. 8 (Navakotisannam), Bam. 9 (Mypali), B. 76, Balungamardhan, Benibhog, D.I. 3 (Orozosporos), D.I. 4 (Orozospores), FR. 13A, FR. 43B, M.L. 1, M.L. 3, N. 136, S.R. 26B (Kalambank), T. 56 (Kalakakkudia), T. 90 (Machakanta), T. 165 (Kajalchampa), T. 380 (Banko), T. 412 (Badshabhog), T. 442 (Kolakartika), T. 608 (Basabati), T. 635, T. 812 (Rangolata), T. 885, T. 1118, T. 1145 (Ussa), T. 1242 (Magura), Jr. 1 (Bobbilihuta), Jr. 2 (Mohl Kunchi), Jr. 3 (Chhittikona), Jr. 4 (Sorumundabali), Jr. 5 (Chudi), Jr. 6 (Ratanmali), Jr. 7 (Karandi), Jr. 8, Jr. 9.
11. Punjab.			N.P. 97, N.P. 130, N.P. 137, Pb. 1 (E.C. 1/57–25), Pb. 2 (Mushkan 41), Pb. 3 (Mushkan 7), Pb. 4 (Lal Nakanda 41), Pb. 5 (Palman suffaid 246), Pb. 6 (Phulputtas 72), Pb. 7 (Sathra 278) Pb. 8 (Begami 337a), Pb. 9 (Ramjawain 100), Pb. 10 (C.M. 7–6), Pb. 11 (Son. 14), Pb. 12 (Malhar 346), Pb. 13 (Basmati 370), Pb. 14 (Jona 349).
12. Uttar Pradesh			Ch. 10 (U.P.), H. 33, H. 64, H. 108, H. 755, N. 10B (Basmati Pilibit), N. 12 (Suffaida), N. 22 (Rajbhog), N. 27 (Banki Pilibit), N. 32 (Baljati), T. 1 (Ramjiwain), T. 3 (Basmati), T. 9 (Duniapet), T. 17 (Bansi), T. 21 (Chawl), T. 22A (Bansi), T. 23 (Kala sukhdas), T. 36 (Jarhan), T. 43 (Sondhi), T. 56 (Jabda), T. 88 (Chakia), T. 100 (Benslot), T. 136 (T. 1 x T. 100).

13. West Bengal		Kalibore 3.	Bhutmuri 36, Badkalamkati 65, Badkalamkati 7, Katak-Ind. 37, Bolder, Dahijira, Kaladubraj, Ajan 246, Kali Kalma, Nonaram sail, Manik Kalma, Sindurmukhi, Raghusail, Basmati, Randhunipagal, Nagra 68/6, Bhasamanik Nagra 41/14, Patnai-23, Patnai 298, Kalma 222, Rupsail 859/37, Seethasail 499, Badshabhog, Kumergore, Kaliboro 1, Kaliboro 2, Bhogjira 1, Bhogjira 2.
CHINA	Ch. 13 (C.N.A. B. Kweichow No. 2), Ch. 45 (996).	Ch. 31 (Black Kernel Glutinous) Ch. 43 (974).	Ch. 1 (Canton Golden Early), Ch. 2 (Nanje hao), Ch. 3 (Hunan victory), Ch. 4 (C.N.A. B. No. 4), Ch. 5 (Szechuan shui Pai Tiao), Ch. 6 (Hunan Thirty culms), Ch. 7 (Chekiang No. 3), Ch. 8 (Chekiang No. 9), Ch. 9 (Rushy late 21–3), Ch. 10 (C.N.A.B. 11–23–613), Ch. 11 (Canton Fine Leaf No. 31), Ch. 12 (Canton Kuan-Yiu Hoien No. 16), Ch. 14 (Kweiyaxy great White Hslen), Ch. 15 (A.H. 28–70 Faith-x Fortuna), Ch. 16 (A.H. 29–218, Blue Rose x Fortuna), Ch. 17 (Pa-Sian Red leaf), Ch. 18 (C.N.A.B. Kweichow No. 8847), Ch. 19 (C.N.A.B. Kweichow No. 9103), Ch. 21 Ch. 22 (Kunming Scented Rice), Ch. 23 (Yunan We Sen Serenli Perfume), Ch. 24 (Yunan Dah-li mature Red), Ch. 25 (Szechuan Dan lung Scented Rice), Ch. 26 (Sung Pan Rice), Ch. 27 (Chang Ming Yunan Rice), Ch. 28 (Sikong Ya-an Red Husk), Ch. 29 (Black Grain No. 9), Ch. 30 (Ho-kiang Dry Field Glutinous), Ch. 32 (Honan Long Purple glutinous) Ch. 33 (Szechuan Early Fine Rice), Ch. 34 (Cheng tu great white Fine Rice), Ch. 35 (Ninger small white Glutinous), Ch. 36 (Yunan Shih Ping purple glutinous), Ch. 37 (Yan San Yellow glutinous), Ch. 38 (Hunan Tzu-Sin Upland Rice), Ch. 39 (C.N.A.B. White Rice), Ch. 40 (C.N.A.B. Land Rice), Ch. 41 (C.N.A.B. Early Yu Rice), Ch. 42 (972), Ch. 44 (988), Ch. 46 (1007), Ch. 47 (1040), Ch. 48 (Ahouchiac), Ch. 49 (Linchou), Ch. 50 (Paiweitsung) Ch. 51 (Yinwei), Ch. 52 (Chinggu), Ch. 53 (Wu Ke haulo), Ch. 54 (Tichiao hualo), Ch. 55 (Aichiao hualo), Ch. 56 (Hunge-hiaochiu), Ch. 57 (Chingchias Chinggu), Ch. 58 (Tainung No. 38), Ch. 59 (Hsin-chu No. 4), Ch. 60 (Taoyrianyinwei), Ch. 61 (Chikechin), Ch. 62 (Paimijih), Ch. 63 (Tuanrzu), Ch. 64 (Chinpaoyin), Ch. 65 (Wuke), Ch. 66 (Paimijin), Ch. 67 (Tuangkuang hualo), Ch. 68 (Chin Shih jih), Ch. 69 (Tai-Nong. 38), Ch. 70 (Chianong No. 18), Ch. 71 (Kaoshiung No. 18), Ch. 72 (Tainong No. 45), Ch. 73 (Taipeh No. 7), Ch. 74 (Shintsuo No. 4), Ch. 75 (Taichung No. 65), Ch. 76 (Chinang No. 2), Ch. 77 (Kaoshiung No. 10), Ch. 78 (Taichung No. 150).
JAPAN			Jap. 1 (Semichi No. 2), Jap. 2 (Omachi), Jap. 3 (Kameji), Jap. 4 (Aikoku), Jap. 5 (Asahi), Jap. 6 (Orhu No. 2), Jap. 7 (Aichi Ashahi), J. 8 (Norin No. 1).
PAKISTAN			Indrasail, Kataktara, Dhepi, Dudsar, Charnok, Tilakkachari, Daudkhani, Atlai, Jessobalam, Panbira, Hatisal, Dharia, Jhingasail, Latisail, Pusur, Bluestick, Pashpai, Daudin, Dular, Chitraj, Marichbati, Nigersail, Hashikalmi, Bangalo, Silver Jubilee, Jaja-1-77, Kangan 1-27.

Table I (Contd.)

Place of origin of varieties.	Resistant	Moderately susceptible.	Susceptible.
RUSSIA.			R. 1 (T. 566), R. 2 (T. 1322), R. 3 (T. 1331), R. 4. (T. 1708), R. 5 (T. 2443), R. 6 (T. 2493), R. 7 (T. 2653), R. 8 (T. 2776), R. 9 (T. 2887), R. 10 (T. 3037), R. 11 (T. 3078), R. 12 (T. 3264), R. 13 (T. 3304), R. 14 (T. 3454), R. 15 (R.I.A.R.I.).
SIAM.			Sm. 1 (Khao Tod Long), Sm. 2 (Mali Thong), Sm. 3 (Champa-Da), Sm. 4 (Nang Mol), Sm. 5 (Leaung On), Sm. 6 (Champa 133), Sm. 7 (Mali Ong), Sm. 8 (Phuang Ngern), Sm. 9 (Pin Kaeo), Sm. 10 (Khao Bhudat), Sm. 11 (Bang Phra), Sm. 12 (Kod Phom), Sm. 13 Nang Tani).
U.S.A.			USA. 1 (CI. 1645–CI. 5309 x Al. II), USA. 2 (Rexoro C.I. 1779), USA. 3 (Portuna), USA. 4 (Nira C.I. 2702), U.S.A. 5 (Texas Patna C.I. 8321), U.S.A. 6 (Colusa-Delitus x Al. II).

number of plants. The preparation of inoculum has been very much simplified in the present case as compared to the methods suggested by Sherf *et. al.* (1947).

The presence of free water on the surface of the leaves for 6 to 10 hours after infection is very important for a successful infection (Hemmi & Nojima, 1931; Sherf *et. al. l.c.*). The fine droplets of water not only help in arresting the inoculum dust on the leaves but also provide sufficient moisture for the growth of mycelia and germination of spores as the case may be, and infection of leaves. Spraying the leaves with water before dusting them with the inoculum, enclosing the seedlings inside the wet curtain, maintenance of a layer of water below the pots and generally the carrying out of inoculation late in the evening after sun-set during the months of August and September (temperature range within the humid chamber during the period of incubation was between 25° to 27.5°C) appeared to provide favourable range of conditions for successful infection of rice by *H. oryzae*.

In the process of infection, as is well known, three distinct phenomena are involved, viz., the germination of infective material which is conditioned by environmental conditions and the presence of exosmosed solutes from the host leaves, the penetration into the leaf and the spread of infection inside the leaf tissues as parasitization proceeds. Two types of resistance of the host tissues are manifested in the process, viz., resistance to penetration and resistance to spread of infection in the tissues after penetration. In judging the relative resistance of varieties as a result of artificial infection under uniform spore load, the number of spots which develop on a leaf may be taken as the index of the resistance offered by the host to penetration, while the stage of development which a spot attains after penetration during a stated interval of 7 days for instance, would reflect the resistance offered by the host cells to spread of infection. Therefore, in scoring the infection and evaluating the resistance of the varieties, due weight was given to non-occurrence of developed spots as an important criterion of resistance. Akai and Asada (1954) working in Japan also recognised two types of resistance in rice varieties to Helminthosporium disease, i.e. resistance to penetration and resistance to disease occurrence. The former was attributed to the mechanical character of the epidermis and the latter to the physiological function of the protoplasm. They observed that while small spots were abundant both in the resistant variety, *Kameji* and the susceptible variety, *Magatama*, the spots in the latter spread three times more rapidly than in the former.

In the present tests with 538 improved varieties, obtained from different States in India and some foreign countries namely China, Japan, Pakistan, Russia and U.S.A, none of the varieties was found to be immune to the disease, i.e., in none of them there was any high degree of resistance to penetration, but resistance to development of infection after penetration has been well marked in the six varieties finally selected ss resistant.

Five of the resistant varieties, i.e., Ch. 13, Ch. 45, T. 141, T. 498-2A and BAM.10 are being tested in more than 40 rice research stations all over India for the last four years to see their performance under local conditions. Results of these tests will be published separately.

Summary

Five hundred and thirty eight released strains of rice obtained from different States in India and from China, Japan, Pakistan, Russia, and U.S.A. were tested for their resistance to Helminthosporium disease.

The methods of testing, scoring the infection and evaluation of relative resistance of the varieties were standardised.

Six varieties Ch. 13, Ch. 45, T. 141, T. 498-2A. Co. 20 and BAM.10 were selected as resistant.

Acknowledgements. The authors are grateful to late Dr. B. B. Mundkur and Dr. K. Ramiah, formerly Director, Central Rice Research Institute, for their advice and keen interest in the study and to Sri M. S. Balakrishnan for his help during the first year of the investigation.

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Cuttack.

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CONTRIBUTIONS TO OUR KNOWLEDGE OF THE CERCOSPORAE OF BOMBAY STATE-II

P. P. CHIDDARWAR

(Accepted for publication October, 10 1959)

Part I of the *Cercosporae* of the Bombay State was recently published by the author (Sydowia, 1959). An account of further studies on this genus including several new species and records are presented in this paper. The types of the new species and varieties are deposited in the Herb. Crypt. Ind. Orient. New Delhi, Commonwealth Mycological Institute, Ferry Lane, Kew, and at the U. S. D. A. Herbarium, Plant Industry Station, Beltsville, Maryland, U.S.A.

(1) *Cercospora acalyphae* Peck. Ann. Rep. N. Y. State Mus. **34** : 48. 1881.

Syn. *C. acalypharum* Tharp. Mycologia **9** : 106. 1917.

Hab. on leaves of *Acalypha ciliata* Forsk. Poona. 12–11–1956. leg. P. P. Chiddarwar. There is no previous record of this species from India and *Acalypha ciliata* is a new host for this species.

(2) *Cercospora anisomelicola* Sawada. Formosa Agr. Res. Inst. Rept. **86** : 166. 1943.

Hab. On leaves of *Anisomeles heyneana* Benth. Matheran. 12–12–1956. leg. P. P. Chiddarwar. There is no previous record of this species from Bombay State; *Anisomeles heyneana* is a new host record for this species.

(3) *Cercospora cajani* P. Henn. Hedwigia. **41** : 309. 1902.

Hab. On leaves of *Cajanus cajan* (L.) Mills. Poona. 26–10–1955. leg. P. P. Chiddarwar. This species is new record for the Bombay State.

(4) *Cercospora citrullina* Cooke. Grevillea. **12**: 31. 1883.

Syn. *C. cucurbitae* Ellis and Everh., Jour. Mycol. **4**: 3. 1888.

C. sechii Stevenson, P. Rico, Ins. Exp. Sta. Dept. Agr. Ann. Rept. 1917-18: 137. 1919.

C. trichosanthis McRae. Ann. Crypt. Exotique **2**: 270. 1929.

C. momordicae McRae, Ann. Crypt. Exotique. **2**: 267. 1929.

C. luffae Hara, Diseases of cultivated Plants, p. 228, 1928.

C. chardoniana Chupp, Monographs, Univ, p. Rico. B. **2**: 245. 1934.

C. momordicae Mendoza, Philipp. Jour. Sci. **75**: 173. 1941.

C. momordicae Sawada, Formosa Agr. Res. Inst. Rept. **86**; 173. 1943.

Hab. On leaves of *Coccinia indica*, W. & A. Poona. 2–1–1954. leg. P. P. Chiddarwar. This species is not previously reported from Bombay State.

(5) *Cercospora cocculi* Syd., Ann. Crypt. Exot. 2: 264. 1929.

Syn. *C. cocculi* Sawada. Jour. Taihoku. Soc. Agr. and Forestry 7: 118. 1942.

Hab. On leaves of *Cocculus macrocarpus* W. &. A. Amba Ghat. 11-1-1955. Leg. P. P. Chiddarwar. There is no previous record of this species from Bombay State and *Cocculus macrocarpus* is a new host record for the species.

(6) *Cercospora gerberae* Chupp & Viegas. Bol. da Soc. Brasil. de Agron. 8: 27, 1945.

Hab. On leaves of *Gerbera jamesonii* Bolus. Poona. 16-12-1956. leg. P. P. Chiddarwar. This species is not previously reported from India.

(7) *Cercospora gaillardiae* Chiddarwar sp. nov.

Leaf spots amphigenous, circular to oval, whitish to pale brown, surrounded by conspicuous dull blackish-brown border, 2–12 mm. in diameter. Stroma light to pale brown, compact, 15.3–25.5 μ in diameter. Fruiting bodies amphigenous, emerging through stomata. Conidiophores in fascicles of 3–20, pale-brown, divergent, straight to slightly curved, 1–5 septate, 1–3, geniculate, 29–115.6 x 4.1 μ. Conidia hyaline, obclavate to acicular, straight to mildly curved, 5–18 septate, gradually tapering, obconic at tip, truncate at base, 31.2–185.3 x 3.4–3.8 μ.

Hab. On leaves of *Gaillardia pulchella* Fougar. Poona. 22-11-1956. leg. P. P. Chiddarwar. No. 13 (Type) Figs. 1, 2 and 3.

Foliorum maculae amphigenae, circulares vel ovatae, albidae vel pallide brunneae, circumdatae margine claro fusce nigro-brunneo, 2–12 mm. diam. Stromata pallide brunnea vel pallide, compacta, 15.3–25.5 μ diam. Fructificationes amphigenae, emergentes per stomata. Conidiophori fasciculati, 3–20 in singulis fasciculis, pallide brunnei, divergentes, recti vel paulum curvati, 1–5 septati, 1–3-geniculati, 29–115.6 x 4.1 μ. Conidia hyalina, obclavata vel acicularia, recta vel tenuiter curvata, 5–18-septata, gradatim fastigata, obconica ad apicem, truncata ad basin, 31.2–185.3 x 3.4–3.8 μ.

(8) *Cercospora hardwarensis* Naras. Sydowia 8: 227–228. 1954.

Hab. On leaves of *Tephorsia purpurea* Pers. Poona. 11-9-1957. leg. T. S. Viswanathan. This species is not previously recorded from Bombay State.

(9) *Cercospora hitcheniae* Chiddarwar sp. nov.

Leaf spots amphigenous, rusty brown, numerous, minute, rounded, scattered, rarely coalescent. Stroma brown, sub-stomatal, loose, 27–58 μ in diameter. Fruiting bodies amphigenous, emerging through stomata. Conidiophores in loose fascicles, rarely non-fasciculate, 3-10 in number, divergent, thick walled, straight to curved, indistinctly 3–6 septate, scars distinct, 1–8 bluntly geniculate, rounded to obtuse at apex, 42.5–68.0 x 3.4–4.5 μ. Conidia sub-hyaline, acicular, straight to curved, 4–7 septate, scars distinct, gradually attenuated, obconic to conic at tip, truncate at base, 74.1–121.9 x 2.2–3.4 μ.

Hab. On leaves of *Hitchenia caulina* Baker. Mahabaleshwar. 19.1.1955. Leg. P. P. Chiddarwar. No. 14 (Type) Figs. 4, 5 and 6.

Foliorum maculae amphigenae, rubiginose brunneae, plurimae, minutae, rotundatae, dispersae, raro coalescentes, Stroma brunneum, substomatale, laxum, 27–58 μ diam. Fructificationes amphigenae, emergentes per stomata. Conidiophori laxe fasciculati, raro non fasciculati, 3–10 numero, brunnei, divergentes, crassis parietibus, recti vel curvati, indistincete 3–6 septati, cicatricibus distinctis, 1–8 obtuse geniculati, rotundati vel obtusi ad apicem, 42.5–68.0 x 3.4–4.5 μ. Conidia sub-hyalina, acicularia, recta vel curvata, 4–7 septata, cicatricibus distinctis, gradatim attenuata, obconic vel conica ad apicem, truncata ad basin, 74.1–121.9 x 2.2–3.4 μ.

(10) *Cercospora holopteleae* Chiddarwar sp. nov.

Leaf spots amphigenous, rounded to ovoid, pale brown when young and becoming dull white with age, surrounded by distinct brown border, not coalescing, 1–9 mm. in diameter. Stroma well developed, brown, compact, 20–40 μ in diameter. Fruiting bodies amphigenous, emerging through stomata on lower and epidermis on upper. Conidiophores in fascicles, numerous, compact, brown, non-divergent, straight, walls sinuous, non-septate, scars distinct, single and apical, rarely beaked, slightly broader at the base, narrowed sub-truncate at apex, 21–30 x 3.4–4.4 μ. Conidia sub-hyaline, sub-obclavate to cylindro-obclavate, rarely cylindrical, straight to mildly curved, 2–8 septate, obconic to sub-obtuse at tip, sub-truncate at base, 23–47 x 3.4–4.3 μ.

Hab. On leaves of *Holoptelea integrifolia* (Roxb.) Planch. Khandala. 8–2–1954. leg. P. P. Chiddarwar. No. 15 (Type) Figs. 7 and 8.

Foliorum maculae amphigenae, rotundatae vel ovatae, primo pallide brunneae, evadentes sordide albae ad maturitatem, circumdatae margine distincto, non coalescentes, 1–9 mm. diam. Stroma bene evolutum, brunneum, compactum, 20–40 μ diam. Fructificationes amphigenae, emergentes per stomata in pagina inferiori, et per epidermidem in pagina superiore. Conidiophori fasciculati, plurimi, compacti, brunnei, non divergentes, recti, parietibus sinuosis, non-septati, cicatricibus distinctis, singuli et epicales, raro rostrati, paulo latiores ad vasin, angustati sub-truncati ad apicem, 21–30 x 3.4–4.4 μ. Conidia sub-hyalina, sub-obclavata vel cylindrico-obclavata, raro cylindrica, recta vel moderate curvata, 2–8-septata, obconica vel subotusa ad apicem, subtruncate ad basin, 23–47 x 3.4–4.3 μ.

(11) *Cercospora ipomoeae* Winter. Hedwigia **26** : 34. 1887.

Syn. *C. viridula* Ell. & Ev., Jour. Mycol. **5** : 70. 1889.

C. alabamensis Atk., Jour. Elisha Mitchell Scien. Soc. **8** : 51. 1892.

C. stuckertiana H. & P. Syd., Mem. Herb. Boissier **8**(4) : 2. 1900.

Hab. On leaves of *Ipomoea hederacea* Jacq. Poona. 17–12–1956. This species has not been previously described from Bombay State.

(12) *Cercospora ipomoeae-illustriae* Chiddarwar sp. nov.

Leaf spots amphigenous, ovoid to slightly irregular, pale brown to greyish in the centre surrounded by dark brown border, not coalescing, often producing shot-holes, 1–6 mm. in diameter. Stroma moderately developed, brown compact, 17.0–28.9 μ in diameter. Fruiting bodies chiefly hypophyllous, rarely amphigenous, emerging through stomata. Conidiophores in fascicles, 7–15 in number, divergent, straight to curved, 1–5 septate, not constricted, 1–10 geniculate, slightly broader at the base, rounded at tip, 34.0–136.0 (rarely upto 173.0 μ) x 3.4–5.1 μ. Conidia hyaline, narrowly cylindric, straight, walls smooth, 1–11 septate, rounded at apex, truncate at base, 20.4–125.8 x 2.5–2.8 μ.

Hab. On leaves of *Ipomoea illustris* Prain and *Ipomoea* sp. Mulsi. 11-1-1957. leg. P. P. Chiddarwar. No. 16 (Type) Figs. 9, 10 & 11.

Foliorum maculae amphigenae, ovatae vel tenuiter irregulares, pallide brunneae vel griseo-albidae in medio, marginibus fusce brunneis, non coalescentes, saepe producentes cavitates iis teli ignei similes, 1–6 mm. diam. Stromata moderate evoluta, brunnea, compacta, 17.0–28.9 μ diam. Fructificationes vulgo hypophyllae, raro amphigenae, emergentes per stomata. Conidiophori fasciculati, 7.15 numero, divergentes, recti vel curvati, 1–5–septati, non-constricti, 1–10–geniculati, paulo latiora ad basin, rotundati ad apicem, 34.0–136.0 (raro usque ad 173.0μ) x 3.4–5.1μ. Conidia hyalina, anguste cylindrica, recta, parietibus levibus, 1.11 septata, rotundata ad apicem, truncata ad basin, 20.4–125.8 x 2.5–2.8 μ.

(13) *Cercospora kamatense* Chiddarwar sp. nov.

Leaf spots amphigenous, irregular, minute, pale brown on upper and surrounded by distinct, dark brown border, pale black on lower, rarely coalescing, 1–2.5 mm. in diameter. Stroma poorly developed, substomatal, sub-hyaline, loose. Fruiting bodies chiefly hypophyllous, emerging through stomata. Conidiophores in fascicles to non-fasciculate, 5–12 in number, loose, brown, slightly divergent, straight to variously curved, 5–13 septate, scars distinct, 1–5 sub-geniculate, rarely branched, gradually attenuated, sub-obtuse at apex, slightly broader at the base, 59.5–136.0 x 4.5–5.1 μ. Conidia pale brown, cylindric to cylindro-obclavate, straight to mildly curved, 3–7 septate, scars distinct, obtuse to sub-obtuse at tip, truncate at base, 25.5–85.0 x 3.4–5.1 μ.

Hab. On leaves of *Cryptolepis buchanani* R. and S. Poona. 18–9–1958. leg. P. P. Chiddarwar. No. 17 (Type). Figs. 12 and 13.

Foliorum maculae amphigenae, irregulares, minutae, pallide brunneae in pagina superiore et circumdatae margine claro brunnae, pallide brunneae in inferiore pagina, raro coalescentes. 1–2. 5 mm. diam. Stroma parum evolutum, substomatale, sub-hyalinum, laxum. Fructificationes vulgo hypo phyllae, emergentes per stomata. Conidiophori fasciculati vel non fasciculati, 5–12 numero, laxi, brunnei, tenuiter divergentes, recti vel varie curvati, 5–13 septati, cicatricibus distinctis, 1–5 subgeniculati, raro romasi, gradatim attenuati, subotusi ad apicem, paulo latiores ad basin, 59.5–136.0 x 4.5–5.1 μ. Conidia pallide brunnea, cylindrica vel cylindrico-obclavata, recta vel nonnihil curvata, 3–7 septata, cicatricibus distinctis, obtusa vel subobtusa ad apicem, truncata ad basin, 25.5–85.0 x 3.4–5.1μ.

(14) *Cercospora lawsoniae-albae* Thirum. & Govindu. Sydowia (In Press).

Hab. On leaves of *Lawsonia alba* Lamk. Poona. 12–9–1956. leg. P. P. Chiddarwar. This species is not previously described from Bombay State.

(15) *Cercospora leeae* Chiddarwar sp. nov.

Leaf spots amphigenous, scattered, darker on upper than on lower, brown to olivaceous, surrounded by dark brown to pale yellow border, coalescent, producing shot-holes, 2–10 mm. in diameter. Stroma poorly developed, pale brown, compact, substomatal, 12–25.5 μ in diameter. Fruiting bodies in compact fascicles, 6–25 in number, pale brown, slightly divergent, straight to curved, walls sinuous, distinctly one septate, rarely 2 septate, scars distinct, 2–5, non-geniculate, bulged at the base, rounded at apex, 13.6–27.2 x 2.5–3.4 μ. Conidia sub-hyaline, cylindrical, often catenulate, straight, walls smooth, 1–4 septate, scars distinct, rounded to truncate at apex, truncate at base, 11.9–34 x 2.5-3.4 μ.

Hab. On leaves of *Leea sambucina* Willd. Matheran. 12–12–1956. leg. P. P. Chiddarwar. No. 18 (Type). Figs. 14, 15 and 16.

Foliorum maculae amphigenae, dispersae, fusciores in pagina superiore quam in inferiore, brunneae vel olivaceae, circumdatae margine fusce brunneo vel pallide luteo, coalescentes, producentes cavitates iis teli ignei similes, 2–10 mm. diam. Stroma paupercule evolutum, pallide brunneum, compactum, substomatale, 12–25.5 μ diam. Fructificationes compacte fasciculatea, 6–25 numero, pallide brunneae, tenuiter divergentes, rectae vel curvatae, parietibus sinuosis, distincte semel septatae, raro bis septatae, cicatricibus distinctis, 2–5, non geniculatae, tumescentes ad basin, rotundatae, ad apicem, 13.6–27.2 x 2.5–3.4 μ. Conidia subhyalina, cylindrica, saepe catenulata, recta, parietibus levibus, 1–4-septata, cicatricibus distinctis, rotundata vel truncata ad apicem, truncata ad basin. 11.9–34 x 2.5–3.4 μ.

(16) *Cercospora leptadeniae* Chiddarwar sp. nov.

Leaf spots indistinct, hypophyllous, producing dark-brown to pale black sooty irregular patches, 1–5 mm. in diameter. Stroma poorly developed, brown, compact, round to flask-shaped, 17–25 μ in diameter. Fruiting bodies hypophyllous, emerging through stomata. Conidiophores in fascicles, 5–20 in number, brown, slightly divergent, straight to curved, wells sinuous, 0–4 septate, 1–3 geniculate, 20.4–76.5 x 5.1–5.6 μ. Conidia cylindric to obclavate subhyaline, straight, 1–8 septate, rarely catenulate, breadth uniform to slightly attenuated, rounded to obtuse at tip, truncate at base. 22.1–113.9 x 4.5–5.1 μ.

Hab. On leaves of *Leptadenia reticulata* W. and A. Poona. 16–12–1956. leg. P. P. Chiddarwar. No. 19 (Type). Figs. 20, 21 and 22.

Foliorum maculae indistinctae, hypophyllae, efformantes textus irregulares, fusce brunneos vel pallide nigros, fuliginosos, 1–5 mm. diam. Stromata non bene evoluta, brunnea, compacta, rotundata vel ampullaeformia, 17–25.5 μ diam. Fructificationes hypophyllae, emergentes per stomata. Conidiophori fasciculati, 5–20 numero, brunnei, paulum divergentes, recti vel curvati, parietibus sinuosis, 0–4-septati, 1–3-geniculati,

20.4–76.5 x 5.1–5.6 μ. Conidia cylindrica vel obclavata, sub-hyalina, recta, 1–8–septata, raro catenulata, uniformiter lata vel tenuiter fastigata, rotundata vel obtusa and apicem, truncata ad basin, 22.1–113.9 x 4.5–5.1 μ.

(17) *Cercospora lettsomiae* Thirum. & Chupp. Mycologia **40** : 356. 1948.

Hab. On leaves of *Lettsomia elliptica* Wight. Khandala. 9–11–1956. leg. P. P. Chiddarwar. This species has not been previously reported from Bombay State.

(18) *Cercospora leucadis* Thirum. & Govindu, Sydowia **7** : 46. 1953.

Hab. On leaves of *Leucas stelligera* Wall. Mahabaleshwar. 20–1–1956. leg. P. P. Chiddarwar. This species has not been previously described from Bombay State.

(19) *Cercospora linariae* Chiddarwar sp. nov.

Leaf spots amphigenous, indistinct, dark brown to pale black, often coalescing and forming irregular patches. Stroma well developed, compact, brown, globular, 20.1–59 μ in diameter. Fruiting bodies amphigenous, emerging through stomata. Conidiophores in compact fascicles, 8–30 in number, brown, thick walled, slightly divergent, straight to mildly curved, margin sinuous, 2–5 septate, scars distinct, 1–2, sub-geniculate, slightly bulged at the base, truncate to sub-truncate at tip, 34–85 x 3.4–4.1 μ. Conidia pale brown, cylindric, short, straight, 2–8 septate, scars distinct, sub-truncate at base, blunt rounded at tip, 23.4–54.6 x 3.4–5.1 μ.

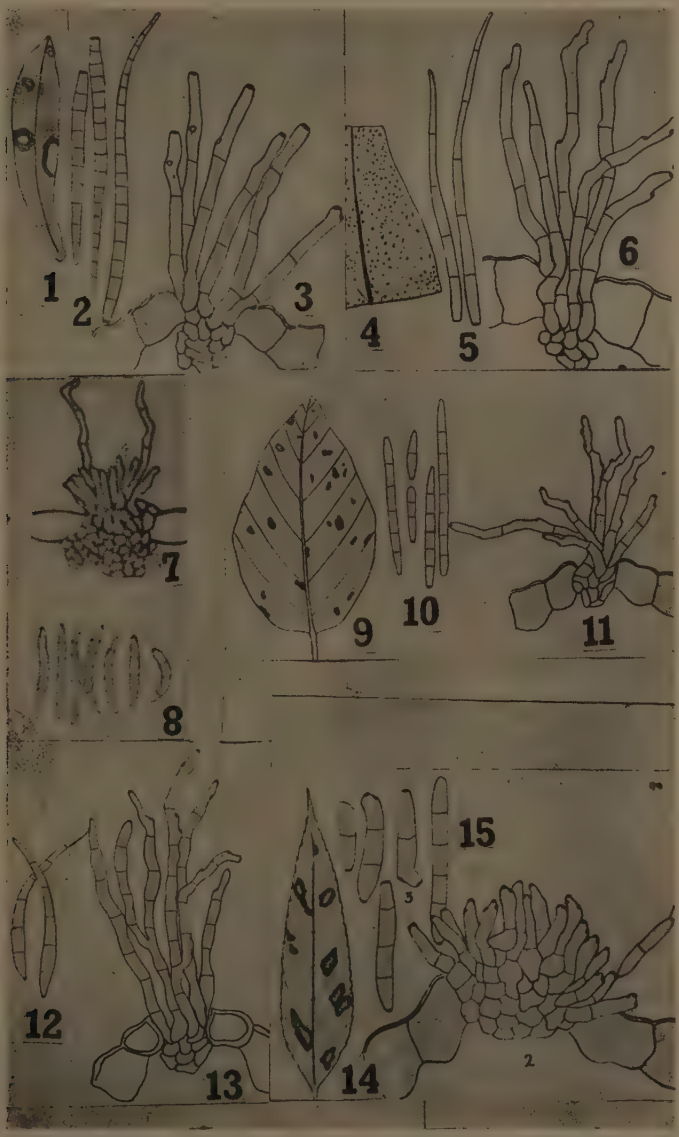
Hab. On leaves of *Linaria ramosissima* Wall. Poona. 16–8–1954. leg. P. P. Chiddarwar. No. 20 (Type) Figs. 17, 18 and 19.

Foliorum maculae amphigenae, indistinctae, fusce brunneae vel pallide nigrae, saepe coalescentes atque efformantes textus irregulares. Stromata bene evoluta, compacta, brunnea, globularia, 22.1–59 μ diam. Fructificationes amphigenae, emergentes per stomata. Conidiophori compacte fasciculati, 8–30 numero, brunnei, crassis parietibus, tenuiter divergentes, recti vel moderate curvati, marginibus sinuosis, 2–5 septati, cicatricibus distinctis, 1–2–subgeniculati, tenuiter tumescentes ad basin, truncati vel subtruncati ad apicem, 34–85 x 3.4–4.1 μ. Conidia pallide brunnea, cylindrica, brevia, recta, 2–8–septata cicatricibus distinctis, subtruncata ad basin, obtuse rotundata ad apicem, 23.4–54.6 x 3.4–5.1 μ.

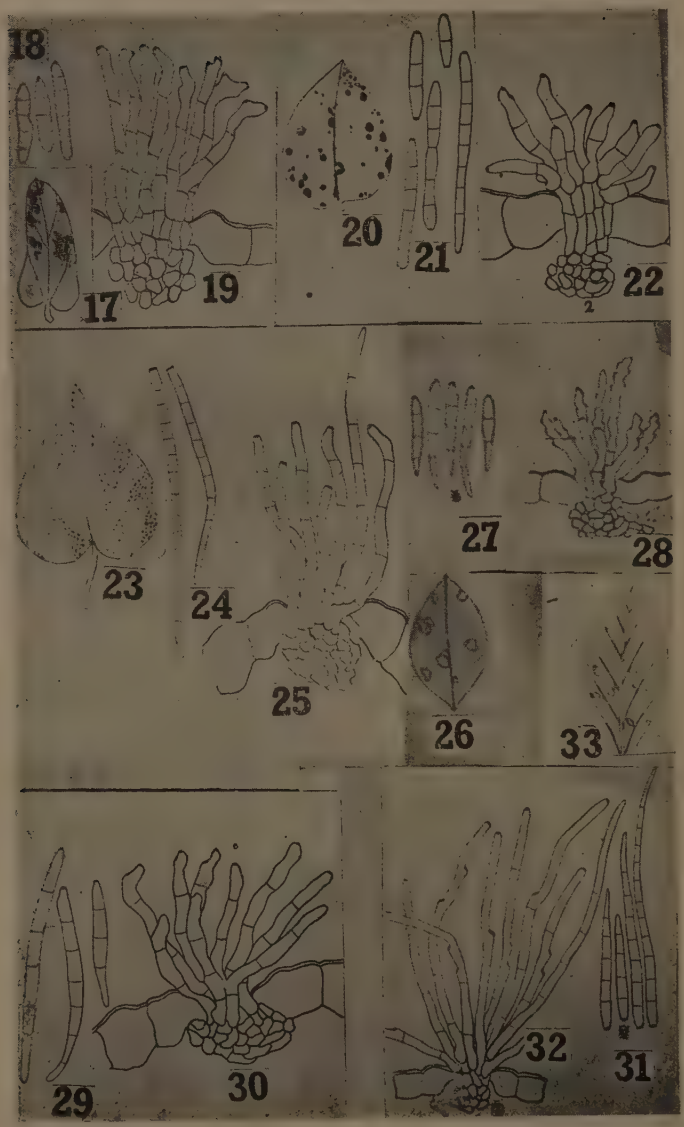
(20) *Cercospora lythracearum* Heald & Wolf.
var. *macrophora* var. nov. Chiddarwar.

C. lythracearum Heald & Wolf. Mycologia **3** : 18. 1911.

Leaf spots amphigenous, irregular, pale brown and becoming fainter with the age, surrounded by dark brown border, not coalescent, 1–12 mm. in diameter. Stroma brown to dark brown, compact, sub-stomatal, 13.6–34.0 μ in diameter. Fruiting bodies chiefly hypophyllous, emerging through stomata. Conidiophores in compact fascicles, 10–35 in number, brown, divergent, straight to slightly curved, margin irregularly undulated, 1–4 distinctly septate, scars indistinct, not geniculate, breadth uniform, rounded at the apex, 26.9–85.0 x 4.2–5.1 μ. Conidia pale brown, cylindro-obclavate, straight to mildly curved, 3–7 septate, scar indistinct, gradually tapering, rounded to obconic at tip, truncate at base, 42.5–95.0 x 3.4–4.2 μ.



Figs. (1–3) *Cercospora gaillardiae*. 1. Habit x nat. size; 2. Conidia x 410; 3. Sorus x 410. (4–6) *C. hitcheniae*. 4. Habit x nat. size; 5. Conidia x 400; 6. Sorus x 400. (7–8) *C. holopteleae*. 7. Sorus x 410; 8. Conidia x 410. (9–11) *C. ipomoeae-illustriae*. 9. Habit x nat. size; 10. Conidia x 290; 11. Sorus x 290. (12–13) *C. kamatense*. 12. Conidia x 400; 13. Sorus x 400. (14–16) *C. leeae*. 14. Habit x nat. size; 15. Conidia x 410; 16. Sorus x 410.



Figs. (17–19) *C. linariae.* 17. Habit x nat. size; 18. Conidia x 430; 19. Sorus x 430.
(20–22) *C. leptadeniae.* 20. Habit x nat. size; 21. Conidia x 400; 22. Sorus x 400.
(23–25) *C. malvacearum.* 23. Habit x nat. size; 24. Conidia x 400; 25. Sorus x 400.
(26–28) *C. oleacearum.* 26. Habit x nat. size; 27. Conidia x 400; 28. Sorus x 400.
(29–30) *C. lythracearum* var. *macrophora.* 29. Conidia x 420; 30. Sorus x 420.
(31–33) *C. petuniae* var. *brevipedicellata.* 31. Conidia x 400; 32. Sorus x 400;
33. Habit x nat. size.

Hab. On leaves of *Lagerstroemia lanceolata* Wall. Castle-Rock. 24–2–1957. leg. P. P. Chiddarwar . No. 35 (Type) Figs. 29 and 30.

Although this fungus resembles *Cercospora lythracearum* Heald & Wolf. in many respects, it has septate and longer conidiophores and distinctly septate pale brown conidia and is, therefore, described as a new variety.

(21) *Cercospora malayensis* Stevens & Solheim. Mycologia **23** : 394. 1931.

Hab. On leaves of *Hibiscus esculentus* Linn. Agri. College Herbarium, Poona. This species has not been previously described from Bombay State.

(22) *Cercospora malvacearum* Chiddarwar sp. nov.

Leaf spots indistinct, amphigenous, scattered, dull dark brown to pale black, tending to coalesce and forming irregular patches. Stroma compact, sub-stomatal, brown, 17–34 μ in diameter. Fruiting bodies amphigenous, emerging through stomata. Conidiophores in fascicles, 6–20 in number, loose, brown, slightly divergent, straight to curved, margin slightly divergent, margin sometimes sinuous, 2–4 septate, sometimes intermixed with sterile conidiophores, scars distinct, non-geniculate, bulged at base, rounded at apex, 62.4–136.5 x 5.1 μ. Conidia hyaline, acicular, straight to curved, margin smooth, 5–21 septate, gradually tapering, conic to obconic at tip, truncate at base 39.1–234.0 x 2.5–3.4 μ.

Hab. On leaves of *Abutilon indicum* Sweet. Poona. 18–11–1955. leg. P. P. Chiddarwar. No. 21 (Type). Figs. 23, 24 and 25.

Foliorum maculae indistinctae, amphigenae, dispersae, obscurate fusce brunneae vel pallide nigrae, coalescentes atque efformantes textus irregulares. Stromata compacta substomatalia brunnea 17–34 μ diam. Fructificationes amphigenae emergentes per stomata. Conidiophori fasciculati, 6–20 numero, laxi, brunnei, tenuiter divergentes, recti vel curvati, marginibus tenuiter divergentibus, nonnumquam sinuousis, 2–4–septati, nonnumquam intermixti conidiophoris sterilibus, cicatricibus distinctis, non-geniculati, tumescentes ad basin, rotundati ad apicem, 62.4–136.5 x 5.1 μ. Conidia hyalina acicularia recta vel curvata, marginibus levibus, 5–21–septata, gradatim fastigata, conica vel obconica ad apicem, truncata ad basin, 39.1–234.0 x 2.5–3.4 μ.

(23) *Cersopora oleacearum* Chiddarwar sp. nov.

Leaf spots amphigenous, rounded to ovoid, pale brown to dull white in the centre, surrounded by dark brown border, not coalescent, slightly pulvinous, 2–8 mm. in diameter. Stroma poorly developed, dark brown, compact, substomatal, 20–30 μ in diameter. Fruiting bodies hypophyllous, emerging through stomata. Conidiophores in fascicles, 5–16 in number, loose, dark brown, divergent, straight, walls smooth to sinuous, generally non-septate, rarely one septate at base, 3–9 strongly geniculate, rounded at apex, broader at base, 40–82 x 3.4–5 μ. Conidia obclavate, subhyaline, straight, 1–4 septate, scar distinct, gradually attenuated, obclavately truncate at base, obconic to sub-obtuse at tip, 35–66 x 4.2–5μ.

Hab. On leaves of *Ligustrum neilgherrense* Wight. Mahabaleshwar. 22–12–1954. leg. P. P. Chiddarwar. No. 22 (Type) Figs. 26, 27 and 28.

Foliorum maculae amphigenae, rotundatae vel ovoideae, pallide brunneae vel obscurate albidae in medio, marginibus fusce brunneis, non coalescentes, tenuiter pulvinatae, 2–8 mm. diam. Stromata paupercule evoluta, fusce brunnea, compacta, sub-stomatalia, 20–30 μ diam. Fructificationes hypophylae, emergentes per stomata. Conidiophori fasciculati, 5–16 numero, laxi, fusce brunnei divergentes, recti, parietibus levibus vel sinuosis, ut plurimum non septati, raro semel septati ad basin, 3–9 geniculati, rotundata ad apicem, latiora ad basin, 40–82 x 3.4–5μ. Conidia obclavata, subhyalina, recta, 1–4–septata, cicatrice distincta, gradatim attenuata, obclavate truncata ad basin, obconica vel subobtusa ad apicem, 35–66 x 4.2–5 μ.

(24) *Cercospora petuniae* (Saito) Muller & Chupp.
var. *brevipedicellata* var. nov. Chiddarwar.

C. petuniae (Saito) Muller and Chupp. Arh. Inst. Biol. Veg. Rio de Janerio **3** : 96. 1936.

Leaf spots amphigenous, circular to ovoid, younger are white with or without peripheral pale brown area and later becoming dull white in the centre with regular pale brown border which becomes darker with the age, not coalescent, 1–4 mm. in diameter. Stroma brown, slightly compact, sub-stomatal, 17.0–25.0 μ in diameter. Fruiting bodies amphigenous, emerging through stomata. Conidiophores in loose fascicles, 5–12 in number, brown, divergent, straight to curved, walls smooth to sinous, 2–4 distinctly septate, scars distinct, 1–3 bluntly geniculate, breadth uniform, rounded at apex, slightly bulged at base, 58.5–173.6 x 4.5–5.1 μ. Conidia hyaline, subobclavate, straight to curved, walls smooth, 3–15 septate, scars distinct, gradually tapering, conic to obconic at tip, truncate at base, 40.0–129.7 x 3.4–4.1 μ.

Hab. On leaves of *Petunia variabilis* Desf. Poona. 21–11–1954. leg. P. P. Chiddarwar. No. 36 (Type). Figs. 31, 32 and 33.

The fungus under study differs from *Cercospora petuniae* (Saito) Muller & Chupp. reported on this host genus in having considerably shorter conidiophores and conidia and is, therefore, described as a new variety thereof.

(25) *Cercospora profusa* H. & P. Syd., Ann. Mycol. **7** : 175. 1909.

Hab. On leaves of *Acalypha indica* Linn. Poona. 10–11–1955. leg. P. P. Chiddarwar. This species has not been previously reported from India; *Acalypha indica* is a new host record for this species.

(26) *Cercospora sydowiana* Chupp. Chupp Monograph on the fungus genus *Cercospora* pp. 363. 1954.

Syn. *C. woodfordiae* Syd., nec. *C. woodfordiae* Petch.
Ann. Crypt. Exot. **2** : 271. 1929.

Hab. On leaves of *Woodfordia fruticosa* (L.) Kurz. Poona. 19–9–1953. leg. P. P. Chiddarwar. This species has not been previously reported from Bombay State.

(27) *Cercospora timorensis* Cooke Grevillea **12** : 38. 1883.

Syn. *C. batatae* Zimmer., Ber. Land. Forstw. Deutsch. Ostafr. **2** : 28. 1904.

C. batatae P. Henn., Bot. Jahrb. von Engler **38** : 118. 1907.

Hab. On leaves of *Ipomoea batatas* (L.) Poir.
Agri. Coll. Herbarium, Poona. This species is new record for Bombay State.

(28) *Cercospora wagateae* Thirum. & Govindu. Sydowia (In Press).

Hab. On leaves of *Wagatea spicata* Dalz. Castle-Rock. 11–2–1957. leg. P. P. Chiddarwar. This species is not previously described from Bombay State.

(29) *Cercospora zinniae* Ell. & Mart. Jour. Mycol. **1** : 20. 1885.

Hab. On leaves of *Zinnia elegans* Jacq. Poona. 12–11–1954. leg. P. P. Chiddarwar. This species has been previously reported from Orissa. (Proc. Ind. Acad. Sci., 1957) but not from Bombay State.

(30) *Cercospora* species.

Hab. On leaves of *Vernonia divergens* (Roxb.) Edgwe. Castle-Rock. 12–12–1956. leg. P. P. Chiddarwar.

(31) *Cercospora* species.

Hab. On leaves of *Crotalaria juncea* Linn. Mahabaleshwar. 10–1–1954. leg. P. P. Chiddarwar.

In conclusion the author wishes to acknowledge his indebtedness to Dr. M. J. Thirumalachar and to Prof. M. N. Kamat for valuable suggestions and guidance given in the course of this work. Grateful thanks are due to Rev. Father Dr. H. Santapau, Ph. D., S. J., Professor of Botany, St. Xavier's College, Bombay, for kindly translating the diagnosis of new species and varieties into Latin.

Maharashtra Association
for the Cultivation of Science,
Poona-4.

PHYSODERMA ON TRIFOLIUM ALEXANDRINUM LINN.

K. S. Thind and S. R. Sharma

(Accepted for publication December 15, 1959)

A *Physoderma* species was found on 'Berseem' (*Trifolium alexandrinum* Linn.) which is an important leguminous fodder crop in the Punjab. A profuse gall formation was observed on the crown of 'Berseem' plants during the months of March to May of 1957 and 1958 in the Khalsa College farms. The disease was found to be more prevalent in the low lying fields which had accumulated rain water. The crop growing on a comparatively dry soil seemed to be largely unaffected by the disease.

Such a chytrid disease does not appear to have been reported previously on 'Berseem'. The present paper deals with the study of the pathogen.

The disease causes severe and profuse gall formation on the lower part of the stems. Mostly all stems in a crown get infected. Roots, leaflets, petioles and upper part of the stems remain unaffected. When first observable the galls appear as minute shining swellings green or concolorous with the stems. As they mature they increase in size and appear gray to brown and dry out in mid summer. They are spherical, cushion shaped or pulvinate and measure 5–11 mm. in diameter. They are crowded and packed together extending up to 4 to 5 inches (Fig. 1 & 2).

The gall-bearing plants appear to be as healthy and reach the same size as unaffected plants. Apart from gall formation, the infected plants do not show any other symptoms, which may help in picking them out from the field.

When cut across, the young gall has a white and brown mottled appearance. In older galls, the interior becomes dark coloured but still shows the characteristic mottled appearance.

Material and Methods: The anatomical structure of the galls as well as cytological studies were made in microtome sections. The material was fixed in formalin-aceto-alcohol and stained with safranin and fast green. For studying the stages of sporangium development and rhizomycelium, young galls were dissected out and mounted in lacto-phenol to which enough acid fuchsin was added to give a cherry-red colour. For germinating the resting sporangia, the mature galls were teased out and the separating sporangia were mounted on drops of water and enclosed in moist chambers at room temperature (25–28 °C.). The zoospores were fixed and stained upon the glass slide by the use of osmic acid and gentian violet.

Figs. 1–2. Photograph of 'Berseem' plants badly infected with *Physoderma* sp. x $\frac{1}{3}$ (approx.)

Morphology of the Fungus: The fungus is composed of non-septate and unbranched hyphae, which develop characteristic turbinate cells. The young hyphae are very narrow, about 0.5 μ wide, and thin-walled. In older galls, however, there occur several hyphae measuring 2–6 μ and with greatly thickened walls and irregular outlines. A young hypha swells terminally to give rise to a turbinate cell containing rather dense protoplasm. Turbinate cells are hyaline and measure 12–16 x 18–20 μ. The extreme end of each of these turbinate cells develops a short very delicate and much branched haustorial process which seems to have an absorptive function as considered by Jones and Drechsler (1920). When a turbinate cell is fully formed, oblique walls cut off a few peripheral segments leaving a central region. Each of the peripheral segments gives rise to a fine hypha that in turn forms a turbinate cell. The resting sporangium arises as a small round body from the enlargement of the axis of the apical haustorial process now at the top of central segment, and rapidly increases in size.

In the present species the maximum number of turbinate cells which arise from any given turbinate cell is three, often, only one or two were observed, but others may have become detached during manipulation.

The young resting sporangium is colourless and develops several branched haustorial processes, which are arranged in a well-defined zone between its equator and the distal pole (Figs. 3 & 5–6). These haustorial processes are not found to persist on the ripe spores. but the small depressions from which they arise can be made out after treatment with clearing agents such as caustic potash and chloral hydrate (Figs. 7–9). The number of these pits varies from nine to eleven, and is most usually ten.

As the resting sporangium increase in size the basal part becomes more flattened (Fig. 4) and a small circular ridge develops separating the upper more convex and lower less convex surfaces. Later on, the wall increases in thickness and becomes brown. The mature resting sporangia are predominantly plano-convex or almost hemispherical, 30–48 x 38–52μ, with a thick, orange-to golden brown, smooth wall and granular refractive contents which include one to several large oily globules. The wall is distinguished into two layers, a thick exospore, and a thin, colourless endospore. Exospore is 1.5–2 μ thick and is hard and brittle, so that in microtome sections it is frequently found broken into irregularly shaped pieces.

A group of slit like pores, usually three in number are present in the less convex surface of the spores (Fig. 9). Bally (1911) and Wilson (1920) observed similar pores in the walls of the spores of *P. rubsaameni* and *P. alfalfae* respectively.

Pathological histology: Galls are the result of both hypertrophy and hyperplasia. The gall is composed principally of thin-walled, parenchymatous cells, which are uninucleate. Longitudinal microtome sections reveal irregular vascular supply, which traverses the gall in various directions (Fig. 12 & 13). The gall develops a vascular system of its own by conversion of parenchyma into tracheary elements, which establish direct communication with the vascular system of the host. The tracheary elements as seen in the macerations of the gall are vessel elements of reticulate and pitted type. Individual vessel elements are short and stunted.

The presence of the parasite seems to cause the dissolution of the thinner cell walls in proximity to the young advancing turbinate cells and leads to the development of cavities in the hypertrophied tissues, in which the resting sporangia are finally found enclosed (Fig. 12). The remains of the protoplasm and nuclei of the host cells may be seen around and among the immature turbinate cells and resting sporangia of the parasite (Fig. 12). The nuclei and nucleoli of the broken down cells enlarge considerably in size and this is accompanied usually by extensive vacuolation of the cytoplasm.

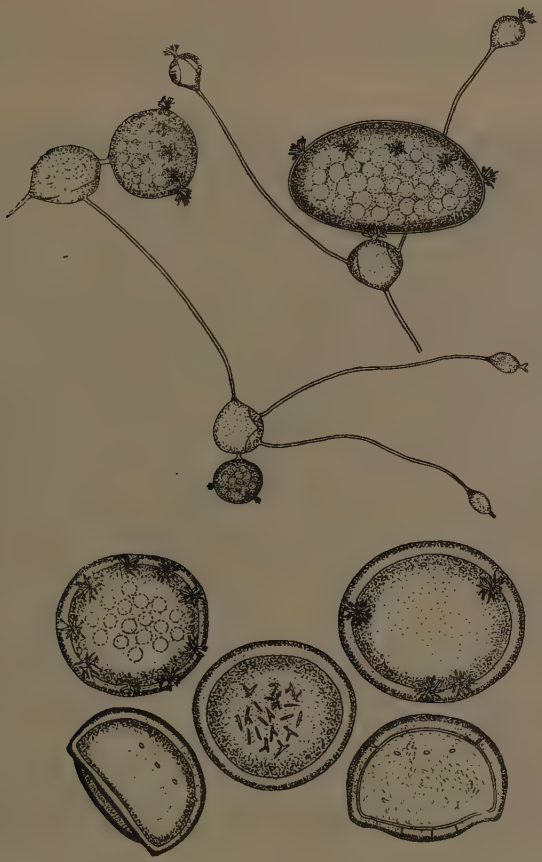
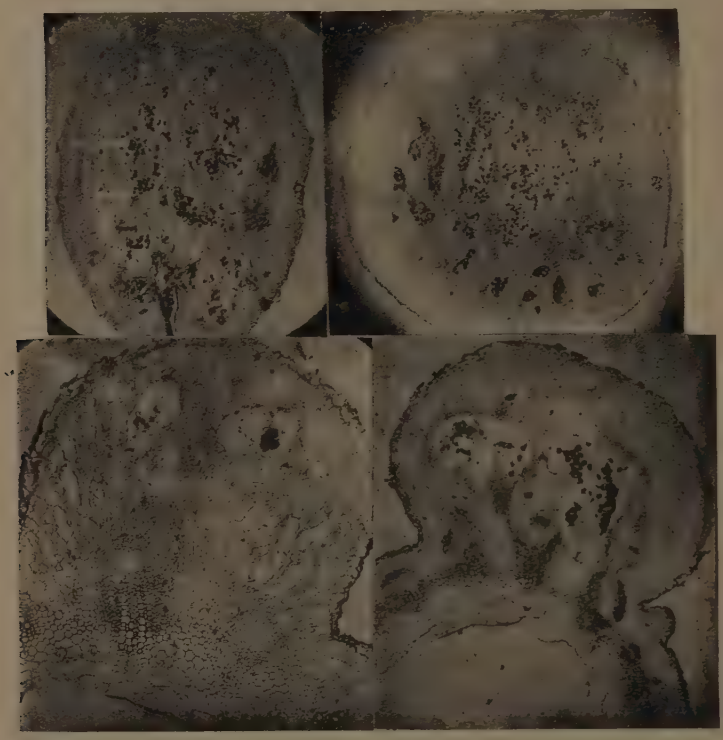


Fig. 3. Immature resting sporangia in various stages of development showing origin of new turbinate cells and sporangia. x 500
Fig. 4. Portion of actively growing thallus of *Physoderma*, showing a few turbinate cells with a nearly mature resting sporangium. x 500
Fig. 5. Nearly mature resting sporangium, viewed from polar end, showing 9 haustoria in zonate arrangement. x 500
Fig. 6. Mature resting sporangium, viewed from polar end. x 500
Figs. 7–9 Mature resting sporangia shown after treating with clearing agents. x 500

The cavities containing the resting sporangia (Figs. 10 & 11) occur sometimes apparently isolated, sometimes in groups, the separate chambers being mostly in open communication with one another, or separated only by intervening cell walls. They show a considerable diversity in form and size, but their contour is usually more or less rounded. The walls bounding the cavities are thicker and more distinct than the ordinary cell walls.

Resting sporangia are numerous, up to 80 in a single cavity. There is some tendency for the resting sporangia to aggregate in groups together with residual host material (Fig. 11).

10 11



12 13

Fig. 10. Photomicrogarph of transverse section of gall showing cavities and resting sporangia of the parasite. x 16 (approx.)

Fig. 11. Photomicrograph of transverse section of gall showing cavities in open communication with one another. The resting sporangia are seen aggregated in groups. x 12 (approx).

Fig. 12. Photomicrograph of longitudinal section of a young gall showing the development of cavities and the irregular vascular supply. x 90 (approx.)

Fig. 13. Photomicrograph of longitudinal section of a mature gall showing irregular vascular supply. x 40 (approx.).

GERMINATION OF RESTING SPORANGIUM: The galls of this species obtained from the fields in the middle of April were placed in garden soil contained in the glass containers which were placed in the laboratory at the ordinary room temperature and the resting sporangia were tested for germination after every two weeks. It was found that after three months the resting sporangia from many of the galls could germinate. It was,

however, found that very slight pressure was often sufficient to start germination in certain cases, and that the most easily germinated resting sporangia were obtained from galls which had become rotted owing to the action of mould fungi and bacteria.

The resting sporangia thus obtained were placed in sterilized distilled water to study their germination behaviour. It was found that many of the resting sporangia germinated at 26–31°C. after 35–48 hours, the precise time differing with different sporangia. The resting sporangia undergo an obvious change when placed in water. The granular appearance disappears and the sporangium seems to be filled with small oily globules (Fig. 14). If the spores are crushed at this stage, numerous globules of fat are freed which stain red with sudan III and bluish green with osmic acid. As development continues, the fat globules in the resting sporangia distinctly become larger and less numerous (Fig. 15). This condition continues until the motile zoospores are set free. In a sporangium which is not viable the fat is frequently congregated into one or two large drops.

In this species no lid is circumscribed and pushed up but instead the sporangium wall cracks irregularly. The development of external zoosporangium as described by Scott (1920) was never observed. Just before the exit of the zoospores a vibratory motion of the sporangium contents is visible through the wall. This is followed by the rupture of the inner wall layer, allowing the zoospores to escape through the cracks in the outer layer. An active movement of the zoospores was occasionally observed in the interior of the sporangium. Usually the sporangium became devoid of oily globules before the zoospores were released (Fig. 16). The zoospores have been observed to escape from the sporangium usually singly.

When freed in water, the zoospores exhibit a great variety of movements. The long cilium, which is quite clearly visible, trails behind when the zoospore is actively swimming. Irregular gyrations are common. Oftentimes the swimming movement may appear to be darting.

The zoospores are somewhat ellipsoidal, approximately 4 x 7 μ while in motion, and bear a prominent fat drop which frequently is seen to shift rapidly when the zoospore is in motion. Periods of activity alternate with periods of passivity, during which the vacuolated conditions very evident. The movements become less vigorous after a time, the ellipsoid or ovoid shape changes to a spherical form, and the long cilium becomes more plainly visible than before, dragging behind passively. Ultimately zoospore undergoes amoeboid movements for a few minutes, comes to a final rest, soon thereafter falling prey to bacteria and animalcules.

The swarming zoospores were fixed and stained upon the glass slide by the use of osmic acid and gentian violet. Each zoospore was found to have a short cilium as well as a long one (Fig. 17). The small flagellum is 5–7 μ long while long one is 13-15 μ. The nuclei of stained zoospores often appear to be within a vacuole because of their position when fixed to the slide.

FUSION OF ZOOSPORES: Fusion stages have been clearly followed in material fixed and stained on the slide (Fig. 18). The fusion of the zoospores was also observed in the water cultures. There seems to be no uniformity as regards the point of attachment. After the two zoospores have become fused together, they zygospore continues to move about for a time before coming to rest. An amoeboid form is finally assumed, and disintergration soon follows on the glass slide.

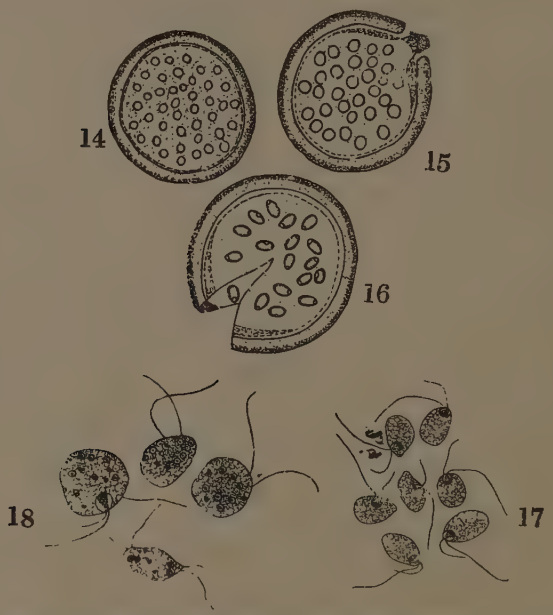


Fig. 14. Resting sporangium when first put into water culture. x 500.
Fig. 15. Zoospore formation almost completed; note rupture of outer wall. x 500.
Fig. 16. Sporangium containing a few zoospores, the rest having escaped through the opening. x 500.
Fig. 17. Free zoospores. x 1150.
Fig. 18. Free zygospores. x 1150.

IDENTIFICATION: Several species of *Physoderma* have been reported on leguminous hosts. The present one differs from all those species in one or the other respects. *Physoderma alfalfae*, which has been reported on *Medicago sativa*, *M. falcata*, *M. rotata* and *M. denticulata* in several countries throughout the world by numerous workers (Karling, 1950), causes marked malformation and stunting of the host, while the one on *Trifolium alexandrinum* does not cause any distortion or stunting of the host. In the present species the maximum number of turbinate cells which arise from any given turbinate cell is three, while in *P. alfalfae* the maximum number according to Jones and Drechsler (1920) is five. In *P. alfalfae* the number of pits in the wall of the resting sporangium through which

the haustorial processes emerge was found by Jones and Drechsler (1920) to be nine to fifteen while in this species the number of pits varies from nine to eleven only. In the present species a small circular ridge of thickening arises in a sporangium separating the upper more convex and lower less convex surfaces while in *P. alfalfae* the zone between the upper and under surfaces is described as rounded. The size of the plano-convex sporangia, however, falls within the range of those of *P. alfalfae*, and on this basis it lies very close to that species. Further work to determine its identity is in progress.

P. trifolii which is reported to occur on *Trifolium pratense*, *T. repens*, *T. montanum* and *T. resupinatum* differs from the present species in that it infects leaves, petioles and peduncles resulting in the production of minute hemispherical warts. The *Physoderma* on *Trifolium alexandrinum*, on the other hand, infects only the lower parts of the stems resulting in the production of comparatively much bigger galls which are spherical, cushion-shaped or pulvinate and are mostly crowded and packed together. *P. vagabunda* which has been reported on *Medicago denticulata* and *Adesmia punctata* in Argentina also differs from the present species in having sporangia which are small (20–22 x 38–40 μ in contrast to 30–48 x 38–52 μ of the present species). Karling (1956) also reports an unnamed species of *Physoderma* on *Medicago arabica* but its sporangia are also small like those of *P. vagabunda*. It induces numerous dark-brown to almost black, protruding, hemispherical galls on both surfaces of the leaves and on petioles and thus can be distinguished from the present fungus on *Trifolium alexandrinum*.

Whether or not the present species on *Trifolium alexandrium* is identical or closely related to any of those species mentioned above remains to be determined from more intensive developmental as well as host range studies.

Summary

Crownwart of Berseem (*Trifolium alexandrinum* L.) caused by a species of *Physoderma*, as observed in Punjab, has been described for the first time from India.

The disease causes severe and profuse gall formation on the lower parts of the stem. Apart from this, there is no visible effect on the plant. The causal fungus produces plano-convex sporangia, which fall within the size range of *Physoderma alfalfae*. Further studies on its identification are in progress.

Acknowledgments. The authors are deeply indebted to Dr. J. S. Karling, Lafayette, Indiana, for valuable suggestions concerning the identification of this pathogen. They are also highly thankful to Prof. P. N. Mehra for providing facilities and encouragement for this study.

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SOME CERCOSPORA SPECIES FROM INDIA-III

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(Accepted for publication December 20, 1959)

The present paper like the previous ones of the series, gives an account of *Cercospora* species, which are either new to the science or are new host or fungus records for India. The specimens have been deposited in Herbarium Cryptogamiae Indiae Orientalis and their numbers indicated in the text.

Cercospora alysicarpi sp. nov.

Leaf spots definite, subcircular to angular, scattered, sometimes confluent, vein-limited, reddish brown in centre, surrounded by narrow dark brown margin, 1–5 mm. in diameter; fruiting amphigenous; stromata small; fascicles dense, spreading; conidiophores brown, tip dilutely coloured, septate, geniculate, not branched, uniform in width, 3.8–6.7 x 30.8 – 115.5 μ; conidia hyaline, acicular, straight to curved, septate, tapering above, base truncate, tip acute, 2.9–4.8 x 38.5–231.0 μ.

On living leaves of *Alysicarpus* sp. (Leguminosae), I.A.R.I., New Delhi, (Delhi), 26-10-1958, G. Lall, H.C.I.O., No. 26271.

Cercospora alysicarpi spec. nov.

Foliorum maculae definitae, subcirculares vel angulares dispersae, nonnumquam confluentes, venis limitatae, rubro-brunneae in medio, marginibus angustis fusce brunneis, diametientes 1–5 mm. Fructificationes amphigenae; stromata minuta; fasciculi densi, patentes; conidiophori brunnei, apicibus dilute coloratis, septati geniculati, non ramosi, latitudine uniformes, 3.8–6.7 x 30.8–115.5 μ; Conidia hyalina, acicularia, recta vel curvata, septata, fastigata supra, truncata ad basin, acuta ad apicem 2.9–4.8 x 38.5–231.0 μ.

In foliis viventibus *Alysicarpi* sp. e familia Leguminosarum in I.A.RI., New Delhi. die 26 octobris anni 1958, G. Lall, H.C.I.O., No., 26271.

Cercospora arisaemae Tai, Chinese Bot. Soc. Bul. 2: 47,1936; Science Rept. Nat. Tsing Hua Univ. Ser. B. 2 : 426, 1937.

On living leaves of *Arisaema* sp. (Araceae), Pusa (Bihar), 13-11-1916, J. F. Dastur, H.C.I.O., No. 26249.

On the leaves, the fungus forms definite spots which are blackish-gray in centre with a darker raised margin and bear clusters of conidiophores on both surfaces. The conidiophores come out of small stromata which are brown, septate, geniculate and measure 5.1 x 20.4–161.5 μ.

The conidia are hyaline, obclavate, septate, tapering above and measure 5.1 x 73.0–195.5 μ.

The specimens in the present collection differ from the recorded description of Chinese specimen in having few geniculate conidiophores and somewhat larger conidia and conidiophores.

Cercospora barringtoniae H. &. P. Sydow, Ann. Mycol. **11** : 406, 1913; Sacc. **25** : 905 1931, as *Cercosporina*.

On living leaves of *Barringtonia acutangula* Gaertn. (Lecythidaceae), Tarai Bhabar Forest Nursery, Lalkua, Nainital (U.P.), 13-3-1959, G. Lall; H.C.I.O., No. 26266.

The fungus forms spots on leaves which are dark brown without a definite border, often adjacent spots coalesce and larger spots are formed. Clusters of conidiophores appear in spots on both surfaces of the leaf. The conidiophores arise from subglobular, dark brown stromata, are olivaceous brown, septate, geniculate, unbranched and measure 3.8–5.5 x 10.5–42.2 μ. The conidia are hyaline, acicular to narrowly obclavate, septate, and measure 2.9–4.8 x 30.8–92.4 μ.

Cercospora brachiata Ellis & Everhart, Jour. Mycol. **4** : 5; 1888; Sacc. **10** : 637, 1892.

On living leaves of *Amaranthus polygamus* L. (Amaranthaceae), I.A.R.I., New Delhi (Delhi), 29-9-1958, G. Lall, H.C.I.O., No. 26221.

On the leaves, the fungus forms distinct spots which are white to tan in centre with a brown margin and bear clusters of conidiophores on both surfaces. The conidiophores arise from a small, dark brown stromata, are olivaceous brown, spreading. septate with long intervals, geniculate, sometimes apex bifurcate, and measure 3.6–4.5 x 46.8–144.0 μ. The conidia are hyaline, acicular, septate, and measure 2.7–4.5 x 36.0–126. 0 μ.

Cercospora buteae sp. nov.

Leaf spots definite, irregularly circular, tan coloured, surrounded by dark brown margin, coalescing to form large spots. sometimes covering the major portion of the leaf, measuring up to 6.5 cm. in diameter; fruiting chiefly epiphyllous, dark, gregarious; stromata dark brown, subglobular, up to 77.0 μ in diameter; fascicles dense; conidiophores short, straight to curved, dark olivaceous brown, rarely septate, not branched, geniculate, 2.9–3.8 x 7.7–30.8 μ; conidia obclavate-cylindric to narrowly obclavate, olivaceous brown, closely septate, straight to curved, 3.8–4.8 x 34.6–116.0 μ.

On living leaves of *Butea frondosa* Roxb. (Leguminosae), State Tarai Farm, Phool Bagh, Nainital, Kumaon (U.P.), 13-3-1959, G. Lall, H.C.I.O., No. 26272.

Cercospora buteae spec. nov.

Foliorum maculae definitae, irregulariter circulares, brunnescentes, circumdatae margine fusce brunneo, coalescentes ad afformadas maculas ampliores, nonnumquam operientes maximam partem foliorum, magnit. Usque ad 6.5 cm. diam. Fructificationes ut plurimum epiphyllae, fuscae, gregariae; stromata fusce brunnea, subglobularia, usque and 77.0 μ diam.; fasciculi densi; conidiophori breves, recti vel curvati, fusce olivaceo-brunnei, raro septati, non ramosi, geniculati, 2.9–3.8 x 7.7–30.8 μ; conidia obclavato-cylindrica vel anguste obclavata, olivaceo-brunnea, proxime septata, recta vel curvata, 3.8–4.8 x 34.6–116.0 μ.

In foliis viventibus *Buteae frondosae* Roxb. e familia Leguminosarum, in State Tarai Farm, ad Phool Bagh, in Nainital, Kumaon, U.P. die 13 martii anni 1959, G. Lall, H.C.I.O., No. 26272.

Cercospora eupatorii Peck, N.Y. State Mus. Nat. Hist. Ann. Rept. **33** : 29, 1880; Sacc. **4** : 444, 1886.

On living leaves of *Eupatorium odoratum* L. (Compositae), Portmont, Port Blair, 2-2-1927, M. Mitra, H.C.I.O., No. 26248.

The fungus forms definite spots on leaves which are vein-limited, reddish brown with a distinct dark margin. Clusters of conidiophores are borne in spots on both surfaces of the leaf. The conidiophores arise from small stromata, are olivaceous brown, simple and measure 3.8–4.8 x 10.5–46.2 μ. The conidia are pale, narrowly obclavate, septate, and measure 2.9–3.8 x 38.5–77.0 μ.

There are several *Cercospora* species on this host genus, out of which only three, namely *C. assamensis* Chowdhury (Lloydia **20** : 134, 1957), *C. eupatorii* Peck and *C. eupatoricola* Govindu & Thirumalachar(Sydowia **8** : 225, 1954) are known to produce definite leaf spots. The species under study agrees with *C. eupatorii* and differs from the other two, in having simple conidiophores and typical narrowly obclavate conidia.

Cercospora guatemalensis Muller & Chupp, Ceiba **1** : 173, 1950.

On living leaves of *Ocimum sanctum* L. (Labiatae), Bhabar Range Forest Nursery, Lalkua, Nainital (U.P.), 27-12-1958, G. Lall, H.C.I.O., No. 26267; **0.** *sp.* (Labiatae), I.A.R.I., New Delhi (Delhi), 17-9-1958, G. Lall, H.C.I.O., No. 26247.

The fungus forms distinct spots on leaves which are white in the centre with a wide dark brown border. Clusters of conidiophores are borne in spots mostly on the upper surface of the leaf. The conidiophores originate from small stromata, are brown, septate, unbranched, geniculate and measure 3.6–5.4 x 28.8–165.6 μ. The conidia are colourless, acicular or rarely obclavate, taper towards the conic tip and measure 3.6 x 72.0–180.0 μ.

Cercospora ocimicola Petrak & Ciferri (Ann. Mycol. **30** : 324, 1932), the other species recorded on this host genus differs from this, in having

indistinct spots, non-geniculate and smaller conidiophores, and coloured, cylindro-obclavate conidia.

Cercospora lantanae - indicae sp. nov.

Leaf spots definite, subcircular to irregular, vein-limited, scattered, dark brown with darker margin, 2–10 mm. in diameter; fruiting amphigenous; stromata small; fascicles few to many, divergent; conidiophores fasciculate, olivaceous brown, straight to variously curved, septate, geniculate, spore scar prominent, not branched, uniform in colour and width 3.8–5.8 x 19.2–161.7 μ; conidia hyaline, acicular, straight to curved, septate, 2.0–3.8 x 23.1–130.9 μ.

On living leaves of *Lantana indica* Roxb. (Verbenaceae). on the road to Kathgodam near Lalkua, Nainital, Kumaon (U.P.), 27-12-1958, G. Lall, H.C.I.O., No. 26273.

Cercospora lantanae - indicae spec. nov.

Foliorum maculae definitae, subcirculares vel irregulares, limitatae nervis, dispersae, fusce brunneae margine fusciore, 2–10 mm. diam.; fructificationes amphigenae; stromata minuta; fasciculi pauci vel plures, divergentes; conidiophori fasciculati, olivaceo-brunnei, recti vel varie curvati, septati, geniculati, sporarum cicatrice distincta, non ramosi, colore et latitudine uniformes, 3.8–5.8 x 19.2–161.7 μ; conidia hyalina, acicularia, recta vel curvata, septata, 2.0–3.8 x 23.1–130.9 μ.

In foliis viventibus *Lantanae indicae* Roxb. (Verbenaceae) in via ad Kathgodam prope Lalkua, ad Nainital in Kumaon, U.P., die 27 decembris anni 1958, G. Lall, H.C.I.O., No. 26273.

Cercospora lythracearum Heald & Wolf, Mycologia **3** : 18, 1911; Sacc. **25** : 909, 1931, as *Cercosporina.*

On living leaves of *Lagerstroemia speciosa* Pers. (=L. *flosreginae* Retz.), (Lythraceae), Tarai Bhabar Forest Nursery, Lalkua, Nainital (U.P.) 13-3-1959, G. Lall, H.C.I.O., No. 26268.

The fungus produces large, irregular infection spots which are leather coloured with a dark purple margin. Clusters of conidiophores are formed in spots on both surfaces of the leaf. The conidiophores are olivaceous brown , small, rarely septate, geniculate, unbranched and measure 3.8–4.8 x 19.0–38.5 μ. The conidia are subhyaline to pale olivaceous, obclavato-cylindric, indistinctly septate and measure 2.9–3.8 x 19.0–61.0 μ.

Cercospora molluginis Halsted, Bull. Torrey bot. Cl. **20** : **251**, 1893.

On living leaves of *Mollugo hirta* Thunb. (Aizoaceae), Kanai Ghat, Sylhet (Assam), 21-5-1905, E. J Butler, H.C.I.O., No. 26269.

The fungus forms distinct spots on the leaves which are circular, pale brown, exactly the same colour as that of a dried leaf, can be separated

only when sooty-coloured fructifications appear on both surfaces of the leaf. The conidiophores originate from small stromata, are brown, septate, geniculate, unbranched and measure 3.8–5.8 x 30.8 – 42.4 μ. The conidia are hyaline, acicular, septate, and measure 2.25–4.0 x 27.0–58.5 μ.

Cercospora pycnanthemicola sp. nov.

Leaf spots definite, subcircular to irregular, small to large, greyish white centre with dark brown border, scattered or sometimes confluent, 0.5–12 mm. in diameter; fruiting amphigenous; stromata slight or none; fascicles few, divergent; conidiophores dark brown, colour and width uniform, not branched, geniculate, spore scar prominent, 4.5 x 36.0 – 90.0 μ; conidia hyaline to subhyaline, acicular, straight to curved, septate, base truncate, tip acute to subacute, 2.7–3.6 x 32.4–186.0 μ.

On living leaves of *Pycnanthemum* sp. (Labiatae), I.A.R.I., New Delhi (Delhi), 17-9-1958, G. Lall, H.C.I.O., No. 26274.

Cercospora pycnanthemicola spec. nov.

Foliorum maculae definitae, subcirculares vel irregulares, parvae vel magnae, griseo-albidae ad medium margin fusce brunneo, dispersae vel nonnumquam confluentes, 0.5–12 mm. diam.; fructificationes amphigenae; stromata minuta vel nulla; fasciculi pauci, divergentes; conidio phori fusce brunnei, colore et latitudine uniformes, non ramosi, geniculati, cicatrice sporarum distincta, 4.5 x 36.0–90 μ; conidia hyalina vel subhyalina, acicularia, recta vel curvata, septata, truncata ad basin, acuta vel subacuta ad apicem, 2.7–3.6 x 32.4–186.0μ.

In foliis viventibus *Pycnanthmi* sp. (Labiatae) in I.A.R.I. New Delhi, die 17 septembris anni 1958, G. Lall, H.C.I.O., No. 26274.

Cercospora triumfetticola sp. nov.

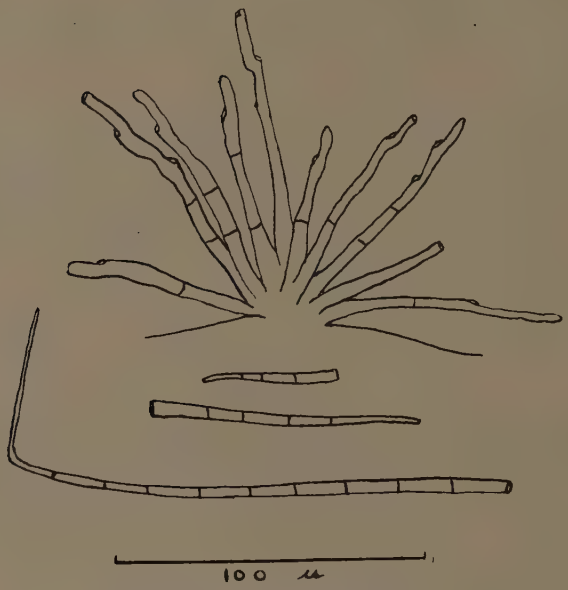
Leaf spots definite, irregular, coalescing to form large spots, reddish brown centre with dark brown margin, 2–18 mm. in diameter; fruiting mostly hypophyllous, but sometimes amphigenous; stromata small; fascicles few to dense; conidiophores olivaceous brown, tip dilutely coloured, geniculate, septate, not branched, irregular in width 3.8–4.8 30.8–73.2 μ; conidia subhyaline, acicular to obclavate, tapering above, septate, straight to curved, 2.9–4.8 x 30.8–115.5 μ.

On living leaves of *Triumfetta rotundifolia* Lamk. (Tiliaceae), I.A.R.I., New Delhi (Delhi), 28-10-1958, G. Lall, H.C.I.O., No. 26270.

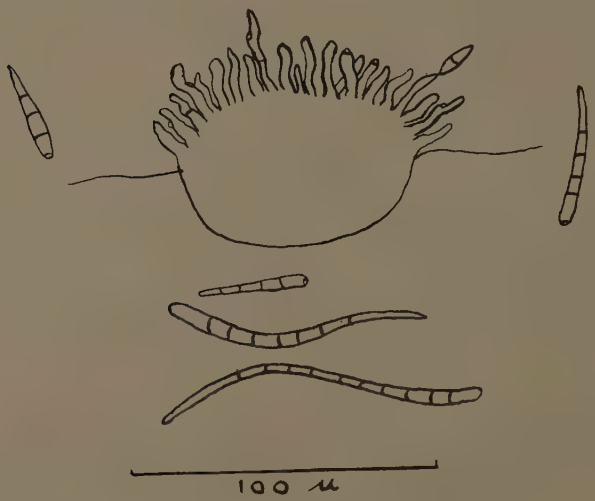
Cercospora triumfetticola spec. nov.

Foliorum maculae definitae, irregulares, coalescentes in maculas ampliores, rubro-brunneae in medio, marginibus fusce brunneis, diametientes 2–18mm. Fructificationes vulgo hypophyllae, nonnumquam amphigenae; stromata minuta; fasciculi pauci vel densi; conidiophori olivaceo-brunnei, apicibus dilute coloratis, geniculati, septati, non-ramosi,

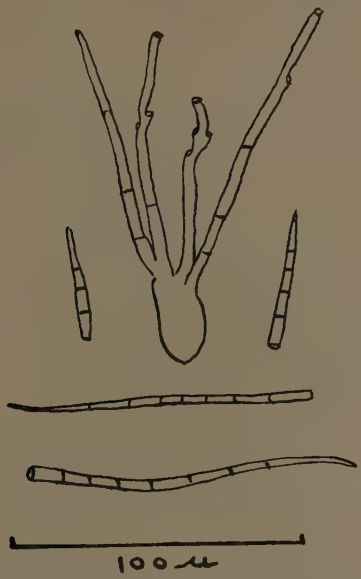
EXPLANATION OF PLATES



1. *Cercospora alysicarpi* — conidia and conidiophores.

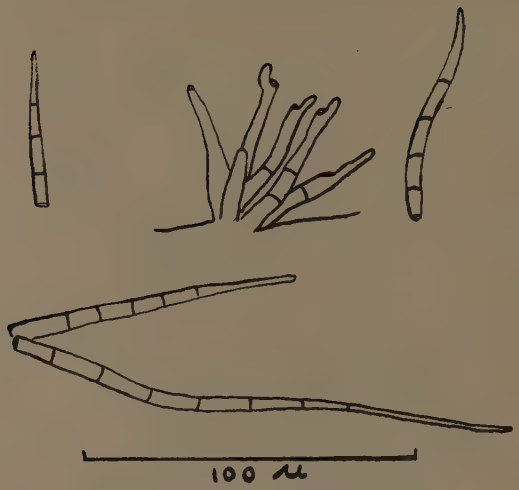


2. *Cercospora buteae* — conidia and conidiophores.



3. *Cercospora lantaneae* — conidia and conidiophores.

4. *Cercospora pycnanthemicola* — conidia and conidiophores.



5. *Cercospora triumfetticola* — conidia and conidiophores.

latitudine irregulares, 3.8–4.8 x 30.8-73.2 μ; conidia subhyalina, acicularia vel obclavata, fastigata supra, septata recta vel curvata, 2.9–4.8 x 30.8 –115.5 μ.

In foliis viventibus *Triumfettae rotundifoliae* Lamk. e familia Tiliacearum, in I.A.R.I. in New Delhi, die 29 Octobris anni 1958, G. Lall, No. 26270.

ACKNOWLEDGMENTS. Sincere thanks are due to Dr. R. S. Vasudeva, Head of the Division of Mycology and Plant Pathology for his keen interest and encouragement throughout the studies. Grateful acknowledgement is made to Mr. J. N. Kapoor, Herbarium Keeper for help in identification of some specimens. We are also indebted to Rev. Fr. Dr. H. Santapau, Head of the Department of Biology, St. Xavier's College, Bombay for rendering latin diagnosis of the new species.

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A NOTE ON STAURONEMA SACCHARI SYD. AND BUTLER, AND ELLISIELLINA DA CAMARA.

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(Accepted for publication October, 30 1959)

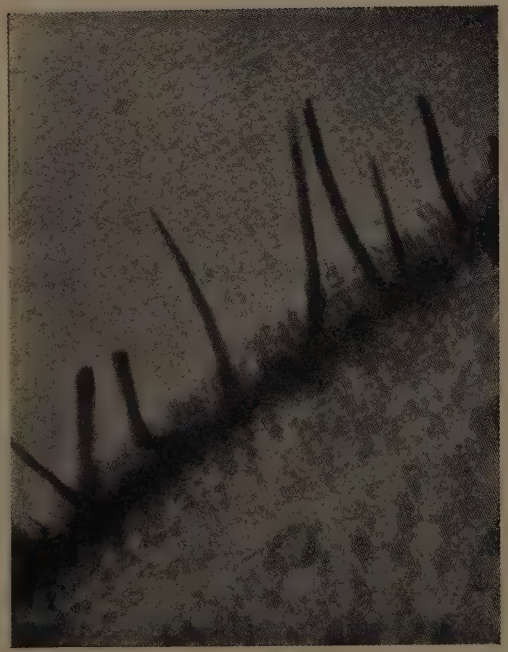
During November, 1955 while making a routine survey of fungi occurring at the farm area of I.A.R.I., an interesting fungus having black round fructifications with prominent stiff dark brown setae was observed. It was found growing saprophytically on a dead culm of sugarcane. The fungus is characterised by large acervuli with dark brown setae and in having hyaline, continuous conidia bearing a cilium at each apex and two in the middle of the body of spore (Fig. 1 a, b, c).

Black, round fructifications are found scattered on the surface of the host, which are sometimes upto 5 mm. in diameter. Cross section through these shows that the acervuli develop under the cuticle. The mycelium within the host is, hyaline, septate, 2–3 μ in width. It collects in the form of round to elliptic hyaline cells 4–5 x 2–3 μ, which together give rise to linear stroma (3–4 layered thick) on which a layer of single celled, hyaline cylindric conidiophores is borne. The conidiophores which measure 14–18 x 3–4 μ may be simple or branched and bear at their tips hyaline, elliptic conidia singly (Fig. 1 b). Thick dark brown setae arise at the same level as the conidiophores and are found scattered chiefly at the periphery. The setae are stiff, bristle like,broader at the base, pointed and lighter coloured at the tip and measure 80–225 x 7–11 μ. The conidia are hyaline, one celled,cylindric or one side curved, 8–13 x 3–4 μ, provided with four whip like appendages, one at each end and two on the body of the spore in the middle (Fig. I c).

The fungus grows best on Oat meal medium in which it forms creeping white mycelium. Three days after its inoculation on oat meal Agar medium at 20–26 °C., it produces numerous black fructifications which are uniformly distributed over the surface of the medium. A few days later a pinkish mass of spores oozes out of the acervuli. The optimum temperature for the growth of the fungus is 23–26 °C. In the beginning it produces pale pigment in the medium which later turns shellpink. There is practically no difference in the morphological characters of the fungus particularly conidia and conidiophores on host and agar culture media, though setae are sometimes smaller in size in the culture.

On the basis of morphological characters this fungus should belong to Melanconiaceae, but it does not resemble any of the known genera of this family. On the other hand it has some superficial resemblance with *Ellisiella* Sacc. of the Dematiaceae in its general habit, though the characters of the conidia are quite different. (Saccardo, P. A. *Fungi italici autographic delineati*, Tab. 781, 1881).

Fig. 1. *Stauronema sacchari* Syd. & Butler



a. T. S. through a fructification showing its melanconia ceous nature, stroma and setae.

b. showing conidiophores simple and branched bearing conidia at their tips singly.

Fig .1

c. Spores with characteristic awl shaped appendages one at each end and two on the spore body.

Fig. 2

Spores, similar to I c observed on leaves of *Oryzopsis caerulescens* infected with *Ellisiellina biciliata*.

The genus *Ellisiella* was established by Saccardo in 1882 (Michelia II, p. 26) and was assigned to Dematiaceae-Amerosporae with the following description: "*Hyphae sterilis erectae, simplices fuscae; conidia fusoidea, sursum longe curvatuo"–rostrata"–Ex E. Caudata.* In 1886 (Syll. Fung. 4 : 315), the following note was added to the description of the genus" *Affinis Colletotricho, a quo pracipue differt, quia non subtecta et conidiis rostraris v. saltem acutis".*

Marchionatto, J. B. (Physis, t. 20, no. 65, p. 115) found that the conidiophores in *Ellisiella cauduta* the type of the genus are elongated at the apex in a filiform appendix, bearing at the end 2–3 spores· The second species included by Saccardo viz. *E. mutica* Winter, has also been shown to have acute conidia. Since these characters do not agree with the description of the genus, he, therefore suggested its emendation. Da Camara, Emmanuele da Sousa in 1949 (Mycetes Aliquot Lusitaniae IX, Agronomia Lusitana p. 72) created a new genus *Ellisiellina* as "*a genus Ellisiella Sacc. vix differt conidia setulis*". He defined the genus as having sub-erumpent black tufts with black elongate setae,conidiophores cylindric to obsolete and conidia fusoid, hyaline, continuous, typically setulate. He treated two species under this genus viz. *Ellisiellina caudata* (Peck) nom. nov. (*Ellisiella caudata* (Peck) Sacc.), thus making it type of the genus and *Ellisiellina biciliata* as new species with the following description. "Fructifications epiphyllous, dot like, erumpent, oblong, separate, dark, 110–115 μ long; sterile hyphae many, erect, rigid, intermixed with conidia, long pointed, without septa, dark, 125–450 x 5–8μ; conidia fusoid, bow like, straight, one celled, both ends narrowly rounded and ciliate, hyaline, 7.5–12 x 2–3 μ; awl shaped setae colourless, 9–12.5 x 0.5–0.75μ; In leaves of *Oryzopsis caerulescens* (Desf.) Richter May, 1948,"

Through the kind courtesy of Director, Estacao Agronomical Nationalis, Sacavem, Portugal we were able to examine two specimens of *E. bicilliata* No. 23959 on *Oryzopsis caerulescentis* (Desf.) Richter; Locality. Extremadura-pr. Cezimbra (Serra do Risco; Leg. P. Silva et Fontes, Det. S. Camara 15-5-1948 Typus and No.41853 on *Dactylis hispanicae* Roth; Loc. Ribatejo. pr. Tomax (Quinta dos Seta Montes); Leg. Garcia Carbal. Det. S. Camara–30.8.1950. Only on the latter specimen, we were able to find fructifications and conidia similar to those reported by us earlier in this note on culms of sugarcane together with *Dinemasporium gramineum* Lev. (Fig. 2).

While examining specimens of fungi affecting sugarcane at the Herb. Cypt. Ind. Orient., I.A.R.I., we came across *Stauronema sacchari* Syd. and Butler, the type specimen of which agreed entirely with the fungus reported earlier in this note.

Stauronema was established by Saccardo in Sylloge Fungorum IV, p. 686, 1884, as subgenus of *Dinemasporium* Lev. for two species with "sporulae cruciata – aristatae". *Stauronema* was later raised to generic rank in 1916 by Sydow and Butler when they also added a new species. *S. sacchari* on *Saccharum officinarum.*

The development of *Stauronema sacchari* in the recent collection reported above shows the fructification of the fungus to be melanconiaceous. In order to determine the nature of fructifications in other species of *Stauronema*, type specimen of *Stauronema cruciferum* (*Dinemasporium cruciferum* Ellis) was examined through the courtesy of Dr. J. A. Stevenson, Principal Mycologist I/C. National Fungus Collections, U.S.D.A. Numerous black dot like fructifications were observed on the leaves of an undetermined grass which on examination under the microscope, were found to be of two types. Where as a large majority of these belonged to *Dinemasporium gramineum*, with their typical excipulate fruit bodies and fusoid, hyaline, curved conidia with awl like appendage at each end; a few fructifications were also found to be of true melanconiaceous type with typically stout dark brown setae and hyaline cylindric to fusoid or one side slightly curved conidia with four awl shaped appendages, one each provided at each end and two on the sides which give the spore (conidium) a star like appearance and fitted exactly the description of *Stauronema cruciferum*. However, at times, one of the cilium may get detached and therefore under different planes of microscope, some of the conidia may appear with three or rarely five appendages. The close superficial resemblance of the fructifications of the *Dinemasporium* with *Stauronema* and their occurence on the same graminaceous hosts, appears to be the chief reason for their inclusion under Excipulaceae.

Specimens studied:-*Stauronema sacchari* Syd. and Butler on stumps of *Saccharum officinarum* (Herb. Crypt. Ind. Orient. No. 1955), Butler, May 1904, Dehra Dun, Typus; on dead stumps of *S. Officinarum* (HC10 No. 25559) J. N. Kapoor, Jan. 1955. New Delhi; Ellis, North American Fungi 755. *Dinemasporium cruciferum* Ellis, n. sp. on dead leaves of various grasses, New Field, New Jersey, June 1881.

Grateful thanks are due to Dr. R. S. Vasudeva, Head of the Division of Mycology and Plant Pathology for his keen interest and encouragement throughout these studies. We are indebted to Dr. M. B. Ellis of Commonwealth Mycological Institute, Kew (England) for suggesting the study of *Ellisiellina*.

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PETIOLE ROT OF CALADIUM BICOLOR VENT. CAUSED BY A NEW STRAIN OF PELLICULARIA FILAMENTOSA

H. K. Saksena

(Accepted for publication December 20, 1959)

Introduction: *Caladium bicolor* Vent., because of rich colour and beauty of foliage, is a popular ornamental in tropical and sub-tropical countries in conservatories and gardens and as a house plant. In spring of 1956 and 1957 plants of *Caladium bicolor* in the Botanical Garden, Kanpur, India, were affected by a brown rot which caused girdling of petiole bases and ultimate withering of the leaves. The disease appeared particularly serious in the warm and wet months. Enquiries and observations made at local nurseries and private gardens revealed the disease to be prevalent in the region. It was considered a most important factor in lowering the ornamental value of *Caladium bicolor* because of premature death of leaves. Repeated isolations from rotting lesions always produced cultures of *Rhizoctonia solani* which were later induced to form the *Pellicularia* stage.

Weiss (1950) listed many parasites causing diseases of *Caladium spp.* Since no report of *Pellicularia* spp. on *Caladium* spp. or other members of Araceae was found in his list or elsewhere in the literature, the present studies on the disease and the causal organism were undertaken.

The disease does not normally become apparent until about 2 to 3 months after planting of corms when the first few leaves have appeared. The first external symptom of basal petiole rot is the abnormal bending of the long and slender petioles under the weight of their leaves. Later the petiole tissues become so softened at the infected point that the petiole falls over or may even break off altogether. The closeness of petiole bases on the short stem makes it possible for the fungus to spread from petiole to petiole. As a result, the diseased plants have only two to three leaves at any one time in contrast to ten or more leaves on the healthy plants. Observations and greenhouse studies have shown the petiole to be susceptible to the rot organism at any stage of development. High humidity and high temperatures favour the development of disease. These conditions are also ideal for the growth of *Caladium*.

The disease manifests itself as brown or tan, sunken, necrotic lesions on the thin margins of petioles immediately above or below the soil level. Young lesions are circular to elongate. They enlarge, coalesce, and become water-soaked. As the wet rot progresses from the margins towards the centre of the petiole the outer tissues collapse and shrivel making the petiole thinner in diameter (Fig. 1, left). The advancing lesions finally girdle the petiole (Fig. 1, right) which topples over. The girdling may

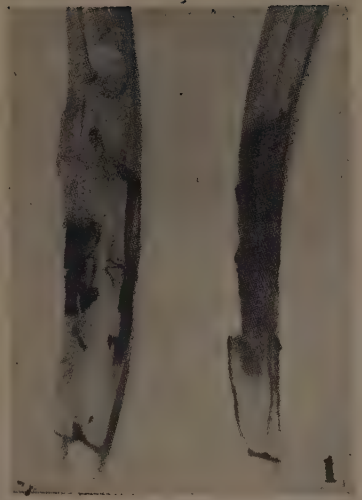

Fig. 1. Development of girdling lesions of *Pellicularia filamentosa* on petiole bases of *Caladium bicolor* in nature.

Fig. 2. Collapsed petioles of *C. bicolor* three weeks after inoculation of soil with *Pellicularia filamentosa*.

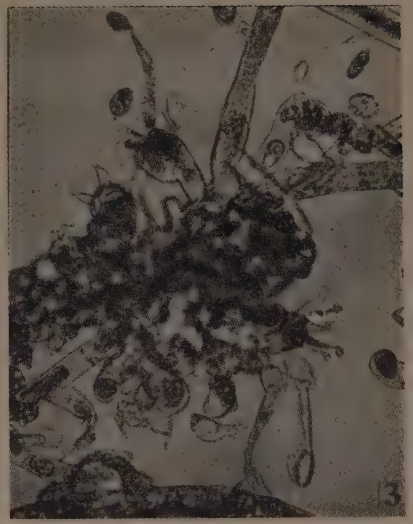

Fig. 3. Clusters of basidia of *P. filamentosa* on water-agar and germinating basidio-spores shed on to the agar surface.

extend upto two inches along the petiole above the soil. Extension may continue down to the sheathing base of the petiole but no infection of the short stem was observed.

Complete girdling normaliy occurs in 15 to 20 days after the appearance of the initial lesions. The leaves may remain green for a few days after girdling of the petiole: but when the cellular invasion of tissue is rapid, there is equally rapid wilting of the entire petiole and leaf. It is possible that in such cases mycelium in the vessels interferes with movement of water through the petiole causing an immediate damaging water deficit in the leaves.

Reduced translocation of food caused by premature death of leaves adversely affects development and subsequent vigour of corms. Corms from diseased plants are of inferior quality, and carry on their surface convex to flat, dark brown sclerotia. Mycelium of *Rhizoctonia solani* is found around the dead basal portion of the petioles.

Material and Methods

Host plants and soil inoculation. The isolates of *Pellicularia filamentosa* obtained from diseased petiole tissues and from sclerotia on corms were maintained on 2% potato-dextose-agar (PDA).

Past studies have shown *P. filamentosa* to include a number of pathogenic strains, some limited to the hosts of a single family and others capable of attacking wider ranges of hosts. The pathogenicity of the petiole rot organisms was, therefore, tested on tomato, lettuce, cabbage, sugar beet, *Caladium bicolor* and *Colocasia antiquorum* Schott, representing five plant families. *C. antiquorum*, which belongs to *Caladium* family Araceae, was included in the tests because of its economic importance as a vegetable crop. *Caladium bicolor* and *Colocasia antiquorum* plants were grown in partially sterilized soil in 9-in. diameter pots. When three to four months old, soil 2 in. deep around the base of the petioles was removed partially uncovering the corms, and mycelial agar mats from 15-day-old PDA cultures were scattered all around. The corms were then covered lightly with soil, and watered. One set of ten inoculated plants of each of the two hosts was kept in a moist chamber in a shaded fern house where a relative humidity of 80 to 90% was maintained. Another similar set was kept uncovered in the fern house near a pool of water,where the relative humidity varied from 65 to 75%. The temperature in the fern house ranged from 28 to 35 C. Ten seedlings each of the remaining test plants were established per glass jar in circles 5 cm. in diameter. Culture disks 2 cm. in diameter from 15-day-old colonies on PDA were placed in the centre of each circle just below the soil level and covered with soil. Three replicates were used and the jars were covered with lids and placed on a bench in the fern house. Suitable controls were maintained in each case.

Method for inducing hymenial development. Hymenial development in artificial media was induced by growing the isolates in rich Potato Dextrore Agar for 30 days and then transferring to 2% water

agar in 2 cm. deep petri plates 'baited' with pieces of host tissue. Pieces 1 cm. long from young petioles were washed in sterilized water several times and their epidermal tissue peeled off aseptically before planting them vertically in a circle at the rate of six pieces per plate. The inoculated plates were placed in the fern house on a raised platform in a trough containing water, and covered with bell jars to provide high humidity.

Results

Pathogenicity studies. The isolates of *P. filamentosa* produced typical symptoms of petiole rot when used to inoculate *C. bicolor*. Brown lesions developed on the petioles of plants kept in the moist chamber in 5 to 7 days after inoculation. Further development of the disease was rapid, and most of the petioles had toppled over in the next 10 to 15 days (Fig. 2). Hymenial development was observed at the bases of some of the petioles in about 25 days after inoculation. The petioles of inoculated plants kept outside the moist chamber survived longer because of slower progress of the disease, and did not develop any hymenium .

The initial symptoms took longer (10 to 12 days) to appear on the petioles of *C. antiquorum*. and the disease effect was less marked. The lesions were most commonly localized on the petiole margin at the place of inoculation and except for few petioles, the lesions did not advance far enough towards the centre to girdle the petioles. The stoutness of *C. antiquorum* petioles may account for the incomplete girdling. *Rhizoctonia solani* was reisolated from diseased petioles of inoculated plants of both the above hosts. The controls remained healthy.

The isolates had no effect on the inoculated seedlings of tomato and sugar beet. Occasional minute, yellow, superficial lesions were noticed on some of the cabbage and lettuce seedlings. Microscopic examination and attempts at isolation failed to provide any clue to the nature of these lesions.

The Pathogen. Although various isolates obtained from infected petioles and from sclerotia on corms showed a certain amount of variation in cultural appearance on PDA, they were morphologically indistinguishable and considered typical of *R. solani* in the mycelial stage. Hard, brown, irregular to round sclerotia, up to 5 mm. in diameter developed on the surface of brown colonies. The main long hyphae and short side branches measured 7 to 12 μ and 9 to 16 μ, respectively, in width.

Hymenial development and identification. Despite the numerous reports of occurrence of the perfect stage of *R. solani* in nature on potato stem, great difficulty has been experienced in reproducing the sexual stage in artificial culture or natural substrate under controlled conditions. Sims (1956) obtained basidiospores on agar surface, plant juice extract, and rooted cuttings of alligator weed under certain conditions. Flentje (1956) induced hymenial development of many isolates on three different substrates—soil surface, base of plant stems, and agar surface. In the present studies, the isolates obtained from infected petioles

were induced to fructify both on natural substrate and on artificial media under controlled conditions. Cultures from sclerotia on corms, though pathogenic, failed to produce basidiospores under identical conditions.

Basidiospores were observed on petiole bases of six of the ten inoculated plants of *C. bicolor*, 25 to 30 days after the plants were put in the moist chamber for pathogenicity tests. The hymenium developed as a whitish grey layer adhering close to the dorsal convex side of the petiole and extending up to 3 cm. above soil level. It lasted for about a week. In culture on 2% water-agar containing small pieces of *Caladium* petiole, it developed as brown spherical clumps of basidia on pieces of host tissue and surrounding agar surface in 18 to 25 days after inoculation. The hymenial development was irregular in that of fifty inoculated plates, development was profused in fifteen, sparse in ten, and absent in the remaining. Hymenium development was good in those plates where moisture condensation had occured on the inside lid and then it lasted longer. Plates in which basidiospores failed to develop, hyphae with typical cymose branching, on which basidia usually form, were observed on the surface but had dried out without further development. Humidity appeared to influence the formation of fructifications. The absence of hymenium on the petiole bases of inoculated plants, of *C. bicolor* kept outside moist chamber could also be due to insufficient humidity.

The average size of basidial structure on inoculated plants and in culture measured as follows. The simple and clavate basidia were 12–18 x 8–11 μ (Fig. 3). There were 2 to 5, most commonly 4, tapering sterigmata which differed in length under different conditions of development. Those produced on host bases were longer (14–25 x 2–3.5 μ) than those formed in culture (7–15 x 1.5 – 3.5 μ). Flentje (1956) reported length of sterigmata to vary considerably with different environmental conditions, particularly humidity, and considered it to be of little use for taxonomic purposes. The basidiospores were ellipsoid to ovoid, hyaline, and 7–11.5 x 5-6 μ in size. The above measurements fall within the limits accepted for *P. filamentosa*.

Numerous chains of moniliform swellings were formed on 2% water-agar in the presence of condensed moisture. The individual cells of the chains measured 20–35 x 14-18 μ. The importance of shape and size of these cells in specific differentiation of *P. filamentosa* and a closely allied species (*P. praticola*), in the absence of the perfect stage, has been recently pointed out by Saksena, (1959).

Control The disease appears to be introduced mainly by the planting of corms from previously infected plants which harbour the sclerotia and mycelium on the surface. Corms kept for seed should be examined, and any that carry sclerotia removed. Preliminary experiments carried out so far indicate that disease incidence can be lowered by dipping the corms for thirty minutes in solutions of corrosive sublimate (1 : 1000) or formalin (1 : 120) after presoaking for one hour in water. This treatment should be carried out immediately before planting. Of 25 plants raised

from treated corms of disease plants, only 5 developed petiole rot, whereas all the untreated controls were diseased.

Discussion. In the pathogenicity tests the *Caladium* strain of *P. filamentosa* failed to cause disease on tomato, lettuce, cabbage and sugar beet, representing four plant families. It was able to parasitize *Colocasia antiquorum* and *Caladium bicolor*. It would thus appear to be specific to the host family Araceae rather than to individual species, and on the basis of host range studies it is regarded as an Araceae strain. Stem-attacking strains specific to three other host families, Compositae, Cruciferae and Solanaceae have already been described by Flentje and Saksena (1957) along with less specialized forms which attacked two or more host families.

Attempts have been made in the past to correlate cultural characters with pathogenicity. Exner (1953) established *formae speciales* for four pathogenic strains of *P. filamentosa* on the basis of cultural characters and disease produced. Flentje and Saksena (1957), working with sixty-eight isolates representing a wide range of pathogenic strains, found no essential correlation between pathogenicity and cultural or morphological characters. In view of the above it appears of little value to separate new strains into *formae speciales* till the nature of pathogenic specialization in *P. filamentosa* is better understood.

Acknowledgments. I am thankful to Drs. M. W. Cormack and C. G. Riley, Director and Forest Pathologist respectively, Canada Agriculture Research Station, Saskatoon, Saskatchewan, for kindly going through the manuscript critically and making useful suggestions.

Summary

A new strain of *Pellicularia filamentosa* has been found to cause a hitherto unreported petiole rot of the horticultural plant *Caladium bicolor*. The disease manifests itself as brown, water-soaked lesions on the thin margins of the basal part of the petiole near soil level. Under favourable conditions, the lesions coalesce and enlarge to completely girdle the petiole and cause its death. Premature death of the leaves lowers the ornamental value of *C. bicolor* and adversely affects development and subsequent vigour of corms.

Isolates of *Rhizoctonia solani* obtained from diseased petiole tissues were induced to form the perfect stage (*P. filamentosa*) under controlled conditions on petiole bases of inoculated plants of *C. bicolor* and on 2% water agar media to which pieces of petiole tissue were added as 'baits'. Comparative pathogenicity tests on tomato, lettuce, cabbage, sugar beet, *Caladium bicolor* and *Colocasia antiquorum*, representing five plant families, showed the petiole rot organism to be a stem-attacking strain of *P. filamentosa* specific to members of the family Araceae. Disease appeared to be introduced mainly by planting of corms from previously infected plants.

It can be controlled by treating the corms with solutions of corrosive sublimate or formalin immediately before planting.

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ERWINIA CAROTOVORA F. SP. ZEAE, A DESTRUCTIVE PATHOGEN OF MAIZE IN INDIA

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A bacterial stalk rot of maize, attributed to *Phytomonas dissolvens* Rosen (*Erwinia dissolvens* (Rosen) Burkholder), was reported by Prasad (1930) as occurring near Pusa, Bihar, India. Since then there has been no other record of a similar disease from this country until very recently when a bacterial stalk and ear rot of maize was found to be fairly prevalent and sometimes extremely destructive to certain strains of maize in the principal maize-growing areas of the country. The causal organism appears to be similar to or identical with *Erwinia carotovora* f. sp. *zeae*, reported by Sabet (1954) from Egypt.

Occurrence and Economic importance. Maize in India is generally grown during the monsoon season under conditions of high humidity, rainfall and temperature, except in Southern India where it is also an important winter crop and is grown under irrigation when the humidity is low, but temperature remains fairly high.

The bacterial stalk and ear rot at first appeared to be most destructive in the higher rainfall regions such as Tarai State Farm in U.P. (about 59" rainfall during the season), but subsequent observations during the *rabi* season at Hyderabad in Andhra State (about 3" rainfall during the season) indicated that the disease was also destructive during the period of low rainfall when the plants were grown under irrigation.

In 1957 this disease was extremely destructive on single crosses growing in double cross production fields at the Tarai State Farm, U.P. After the observations were made at this location and the seriousness of the disease was recognised, a search was made for the disease in the States of Rajasthan, Andhra, Delhi and Kashmir, where maize is one of the important food crops grown. Plants showing symptoms similar to the disease recorded at the Tarai State Farm, U.P., were found in all these locations (Table I).

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TABLE I. Distribution and intensity of the bacterial stalk and ear rot of maize in different parts of India where the survey was made (*K=*Kharif;* R=*Rabi*).

Place	Year	Strains of maize on which the disease was recorded	Percentage damaged plants
Tarai State Farm, U.P.	1957 K*	Double cross production of U.S. 13 and U.S. 578.	15 to 22
	1958 K	U.S. Hybrids; Local variety KT 41	Up to 12
Hyderabad, Andhra	1957 K	Yield Trial Fields	less than 5
	1958 R	Demonstration plots of N.C. 27 and V.L. 23	Up to 33
Ajmer, Rajasthan	1957 K	Yield Trial Fields	5 to 10
Srinagar, Kashmir	1957 K	Yield Trial Fields	less than 2

ISOLATION. A large number of isolations were made from maize plants in the field which showed either a rotting of the basal portion of the stalk or of ear and ear shank (Fig. 1), the affected parts being dark brown, soft, water-soaked and sunken with a strong odour of decay. The leaves (Fig. 2) and ear covers were also infected, becoming water-soaked and slimy. The affected portions were cut into small pieces, dipped in alcohol, and flamed. Each portion was then placed in a drop of sterilized water on a sterilized slide for teasing apart the inner tissues which were full of bacteria. This bacterial suspension was either streaked on nutrient agar or used for pouring dilution plates when grayish-white bacterial colonies appeared within 24 hours. Besides these colonies, which were predominant in all the isolation plates,a few yellow colonies also appeared in some plates as secondary growth and were discarded as they consisted of cocci. The grayish-white bacterium was purified by picking separated single colonies. Since all the cultures so obtained closely resembled each other, only six isolates were taken up for detailed study.

INOCULATION TESTS. The six isolates were separately inoculated into 1 and 2 months old potted plants of maize variety Kansas 1639 raised from surface-sterilized seeds. This variety had been found to be highly susceptible to the disease under field conditions. The inoculations were made by either injecting the bacterial suspension into the stalk near the growing point or by inserting it into the funnel with and without injury. Suitable controls were kept in each case which received the same treatment except that no inoculum was used. All the inoculated and control plants were then kept in moist chambers for 48 hours, after which they were removed and placed on a bench in the glasshouse for observations.

All the six isolates were found to be pathogenic by the hypodermic syringe method only (Fig. 3). The infection started as a water-soaked

Fig. 1.

Fig. 2.

Fig. 3.

area with longitudinal brown discolouration at the point of inoculation within 2–3 days, which rapidly advanced, covering the whole thickness of the stalk within 5 days. After this, the leaves started yellowing and drying. The infected tissues at first were soft, but later on they turned into a dry mass of shreded, easily disjointed fibres, remnants of the fibro-vascular bundles. Finally the stalk gave way at the point of inoculation and the whole plant died. Two months old plants appeared to be more rapidly infected as compared to the one month old ones. In the latter case also the infection first appeared within 72 hours, but subsequently the rate of infection in a few cases could not keep pace with the growth of the plant with the result that ultimately a healthy plant was obtained.

Isolations were made from the diseased plants and a bacterium, similar to the original isolate, was secured which produced typical stalk rot symptoms in maize plants on re-inoculation. It also produced typical soft rot in potatoes, carrots and onions within 48 hours under controlled conditions. The disease could be easily reproduced with the culture isolated from the infected vegetables.

In host-range studies *jowar*, *bajra* and *tobacco* were successfully infected by the hypodermic syringe method.

DESCRIPTION OF THE PATHOGEN. The Manual of Methods for Pure Culture Studies of Bacteria (Society of American Bacteriologists, 1951) was referred to for the techniques followed here. Sugars were incorporated as 1% solutions in the basal peptone-free medium [$(NH_4)\ H_2\ PO_4$, 1.0 g.; Kcl, 0.2g.; $MgSo_4.\ 7H_2o$, 0.2g.; and distilled water, 1 litre], adjusted to pH 7.0. Brome thymol blue was used as an indicator for observing the change in pH reaction of the sugar solutions after inoculation. Other media used for cultural studies were prepared according to the standard methods as given by Levine and Schoenlein (1930).

MORPHOLOGY: The pathogen is a short rod, measuring 1.5–3.0 μ x 0.5–0.7 μ (negative staining), motile with peritrichous flagella, usually in pairs, non-capsulated and non-sporing. It readily stains and is Gram-negative, but not acid-fast.

CULTURAL CHARACTERS: The organism is facultative anaerobe. The optimum temperature for growth is 30°–35°C., the minimum being 5°C. and the maximum 40°C. The thermal-death-point lies between 50°–52°C. Colonies on nutrient agar are grayish-white, raised, glistening and smooth with entire margins. Growth on P.D.A. is scanty and white to creamy white in colour with no apparent diastatic action. Nutrient broth and Uschinsky's solution become turbid with the formation of sediment and very thin pellicle.

BIOCHEMICAL REACTIONS; Acid and gas are produced from raffinose, dextrose, arabinose, salicin, mannitol and sucrose, but acid only from lactose and glycerol. Starch is not hydrolysed. Methyl-red test is positive, but not Voges—Proskauer test. Indole, hydrogen sulphide and ammonia are formed in traces, while nitrites are produced from nitrates.

Gelatin is liquefied, the shape of liquefaction being stratiform. In litmus milk, litmus is reduced and coagulation with subsequent peptonization takes place.

IDENTITY OF THE PATHOGEN: Four bacteria, namely, *Pseudomonas lapsa* (Ark) Burkholder, *Erwinia dissolvens* (Rosen) Burkholder, *Erwinia carotovora* (Jones) Holland and *Erwinia carotovora* f. sp. *zeae* Sabet, have been reported from different parts of the world to cause stalk rot of maize (Ark, 1940; Rosen, 1922; Boewe, 1949; Sabet 1954). Recently, an unidentified species of *Erwinia* has also been shown to cause stalk rot of irrigated corn in U.S.A. (Kelman, Person and Hebert, 1957). A similar disease seems to have been described from Australia as well, although its pathogen has not been identified (Ludbrook, 1942). The description of the maize pathogen given above clearly shows that it belongs to the genus *Erwinia*. It, however, differs from *Erwinia dissolvens* in its ability to liquefy gelatin and in its inability to hydrolyse starch. Moreover, the organism under study is a true soft-rot bacterium and is able to attack both vegetables and maize plants which puts it nearer to *Erwinia carotovora* f. sp. *zeae*.

CONCLUSION. In the present study, *Erwinia carotovora* f. sp. *zeae* has been shown to be the causal agent of ear and stalk rot of maize for the first time from this country. It appears that, with the intensification of maize breeding programme during the last two years, the disease has assumed serious proportions as is evident from the fact that some of the potentially important exotic varieties of maize have been found to be severely affected and a few of the indigenous varieties have also shown a high percentage of infection. The performance of these lines in the experimental plots is disconcerting, but it would be far worse if there were similar destruction on several million acres in farmers' fields.

This is the clearest possible warning of the menace to maize production if combinations are made in which susceptibility to the bacterial disease predominates. To avert such a possible catastrophe,it is essential to obtain the necessary facts regarding the disease and its pathogen in order that they be taken into consideration in the breeding programme. Information regarding the occurrence of parasitic races, if any, within the pathogen is not available and this study is necessary to guard against the danger of developing varieties which may later succumb to races which are not now widely distributed and prevalent. The present isolate seems to be aggressive on the basis of its performance on vegetables and maize plants, as also in its ability to infect *bajra*, *jowar* and tobacco, but the possibility of coming across even more virulent forms cannot be ruled out. Furthermore, there has so far been no opportunity to study etiology of the pathogen in the field under Indian conditions. Work on the survival and host-range of the pathogen, modes of transmission of the disease and effect of environmental factors on disease development would require to be immediately taken in hand.

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OCCURRENCE OF CHONDROMYCES IN THE RHIZOSPHERE OF PLANTS

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That the rhizosphere of plants abounds with greater numbers of microorganisms than the free soil has been known for a long time. Investigations by Agnihothrudu *et al.* (1955) and Agnihothrudu (1956a, 1957a, 1957b and 1958) have revealed a great variety of species of fungi in the rhizosphere of plants in Southern India. Members of the interesting group, Acrasiales were also isolated and reported from this microhabitat (Agnihothrudu, 1956b).

Chondromyces pediculatus Thaxter and *C. aurantiacus* (Berkeley *et* Curtis) Thaxter, organisms belonging to the Polyangiaceae of the order Myxobacteriales were very often observed by the senior author in the rhizosphere platings of plants collected in Southern India. Fructifications of *C. aurantiacus* were recently identified in root samples of cotton plants sent by Dr. (Miss) K. Bhuvaneswari from the University Botany Laboratory, Madras. The foregoing evidence and the frequency with which *Chondromyces crocatus* Berkeley *et* Curtis has appeared on the root surface of *Crotalaria anagyroides* H. B. K. and *Tephrosia candida* D. C. locally afford added evidence to the supposition that these organisms comprise, perhaps, one of the characteristic components of the soil microflora although they were generally believed to be purely coprophilous in habit occurring on the dung of herbivores.

The object of this short note is to present the description and illustration of *Chondromyces crocatus*, one of the interesting members of the Myxobacteriales which has been observed repeatedly occuring in the rhizosphere of green crops growing in the campus of Tocklai Experimental Station. So far, the authors are not aware of any report of the occurrence of this organism in Indian soils.

The organism makes its appearance on root pieces after nearly a month of incubation. Prior to the appearance of the fructifications, the pale orange-red to watery swarm stage is seen creeping over the surface of the substratum. The vegetative cells comprising the pseudoplasmodium are cylindrical rods with obtuse ends and measure from 2 to 8 by 1.2 to 1.8 μ in diameter. The swarm stage gradually heaps up in places and resolves itself into characteristic fruit bodies which are straw-yellow to orange or saffron-coloured. The fructifications are typically stipitate, the stalk is plicate in being covered with longitudinal striations and is not infrequently skewed. The fruit bodies assume slightly brick-red colour with age. In most of the specimens the stipe is wide at the base, tapering towards the extremity. The distal part of the cystophore is drawn into thin, ramified laterals which bear at their tips groups of cysts. The total height of the fructifications varies from 500 μ to 1 mm. and the diameter of the stipe at the widest part is 80 to 150 μ and at the narrowest part 50 to 80 μ The ramifications in a few instances are sparse while in others profuse and

show an imperfect dichotomous pattern. The ultimate laterals measure 42 to 74 by 7 to 10 μ and are somewhat inflated at the extremities. The knobs measure up to 12 μ in diameter. The resting cells are enclosed in cysts which are borne on short pedicels measuring 4 to 6 μ in length and are fusiform to begin with, becoming gradually widened at the base with maturity when they are typically conical in appearance. The cysts are straw yellow at first but finally turn golden yellow. Mature cysts drop away leaving pedicels on the inflated extremities of the ultimate laterals of the cystophore. The cysts are thin-walled, show invariably a hilum and measure 12 to 44 by 6 to 15 (20) μ in diameter. The resting cells within the cysts are 2 to 4 by 1 μ in diameter. From the above description it may be noted that the species occurring locally differs from the description given by Breed *et al.* (1957) in showing a wider range in size of the fructifications and cysts.

Cysts placed in a moist chamber were observed to germinate in a day in fresh collections. The contents contract from the wall of the cyst showing prominently the individual resting rods which are otherwise not very clear. The wall of the cyst deliquisces at the base and the rods escape in a regular stream until the cyst is left completely empty. Attempts to culture the organism were not successful.

The specimens are deposited in the Mycological Herbarium, Tocklai Experimental Station.

The authors are grateful to the Director, Tocklai Experimental Station, Indian Tea Association for permission to publish this note and to Mr. K. C. Sarmah for his encouragement.

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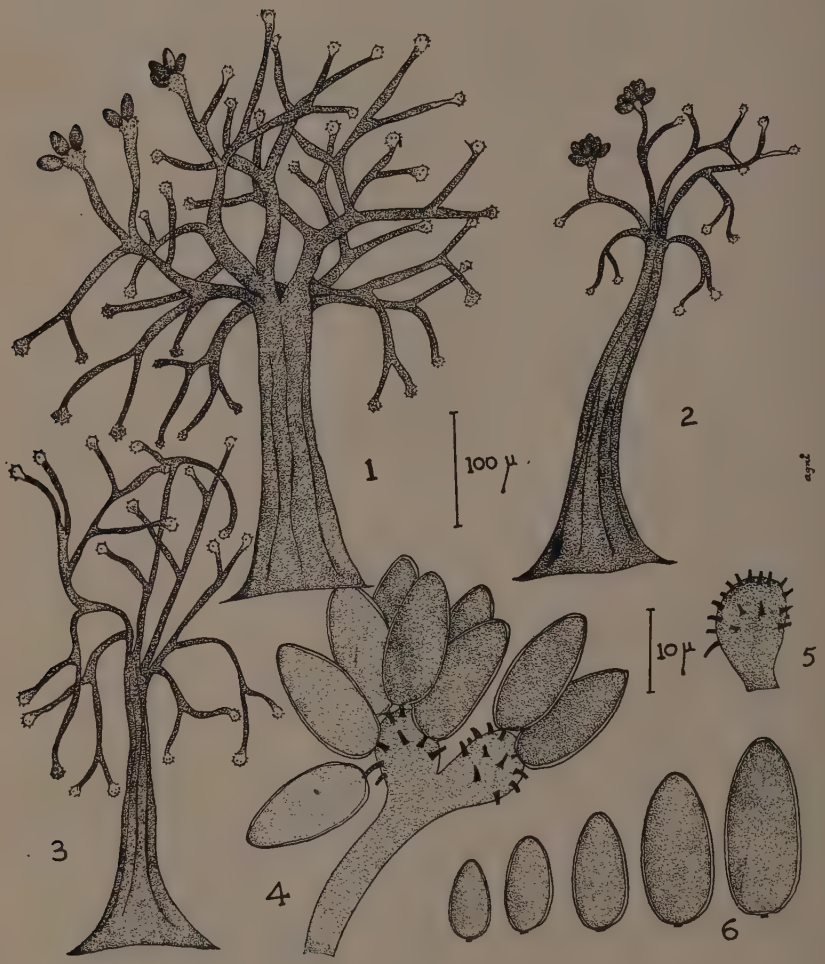

LEGEND FOR TEXT FIGURES

Chondromyces crocatus Berkeley et Curtis.

Figs. 1-3. Different types of fructifications showing the ramifications of the cystophore.

Fig. 4. Extremity of the ultimate lateral of cystophore bearing cysts on short pedicels.

Fig. 5. Knobbed extremity of an ultimate lateral showing the pedicels of the cysts.

Fig. 6. Cysts.

STUDIES ON A LEAF SPOT DISEASE OF SPINACH CAUSED BY CLADOSPORIUM VARIABILE (COOKE) DE VRIES IN RAJASTHAN

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Spinach (*Spinacia oleracea* L.) is grown throughout India all the year round wherever irrigation facilities are available, otherwise it is sown in the months of July-September in Northern India and picking of leaves continues upto the middle of April. In Rajasthan, two varieties viz., savoy (Prickly seeded) and smooth leaf type (round seeded) are grown. Prickly seeded variety is preferred in Kota division (Heavy soil area) only.

During recent years, the prickly seeded variety of spinach was observed to suffer from a destructive disease recognized by the appearance of numerous dirty white water-soaked spots on the upper surface of the leaf. The symptoms of the disease closely resembled those caused by *Heterosporium variabile* Cooke, described by Padwick (1945). The disease is wide spread in Kota district and is responsible for considerable damage to the crop. No detailed investigations of the disease however seem to have been made so far. The results of the work under-taken on this disease in this laboratory are reported in this paper.

The early symptoms of the disease consist of numerous scattered sharply defined, whitish spots on the upper surface of the leaf. The spots are circular 1 to 3 mm. in diameter and are surrounded by a very narrow shrivelled band. The individual spots may enlarge and coalesce towards the tip of the leaf. Finally under moist conditions the leaves are almost covered with coalesced circular spots with fungus growth. At first the spots are mainly epiphyllous but later on they are more or less equally abundant on both sides of the leaf.

The mycelium is both inter and intracellular. Conidiophores occur singly and rarely in groups of two or three. Conidiophores vary considerably in size 46.8–172.8 μ x 4.3–5.5 μ (mean 123.6 μ x 4.4 μ). The tips of the conidiophores are swollen and rounded with distinct scars on them.

The conidia are borne in chains and are thick walled greyish brown in colour, echinulate, 1 to 4 celled, ovoid to cylindrical, slightly constricted at the septa with a broadened basal cell showing a conspicuous scar.

Pure culture of the fungus was obtained by usual plating and single spore culture technique. Pathogenicity of the fungus was proved by spraying a conidial suspension, from two weeks old culture grown on

Potato Dextrose Agar, on uninjured one month old plants. The inoculated plants were kept covered by bell jars and high humidity was maintained by spraying distilled water twice a day. The initial symptoms appeared within four days of inoculation and typical spots developed after six days. The fungus could be reisolated from the infected leaves and was found to be identical with the original fungus. Conidia germinated readily in distilled water, 4 per cent glucose solution and spinach decoction and took about $3\frac{1}{2}$, 6 and $4\frac{1}{2}$ hours respectively at room temperature.

To study the mode of infection,spores were atomized on the spinach leaves. Infection took place directly through cuticle. In no case, stomatal infection was observed. Infection occured directly by the germ tube and appresorium or any similar structure was never formed. The time taken by the germ tube to penetrate the cuticle was about 22 hours at room temperature (18°C to 20°C.) and although small initial spots appeared after 3 days, typical symptoms were observed after 6 days. Infection took place only when the atomized plants were kept in moist chamber.

The fungus was grown at 23°C on 2% P.D.A., Oat Agar, Corn meal agar, Glucose Agar, Sabouraud's and Brown's media. It is a slow growing fungus. Small white cottony dome-shaped colonies were formed in 3 days which became olivaceous green later on. A light pink pigment diffused frequently into the Agar. Mycelial growth was very poor in all the media. There was practically no aerial mycelium on any synthetic medium. The fungus sporulated very profusely on all the media tested producing 1 to 3 celled conidia. On Sabouraud's medium, however, 1–2 celled conidia only were formed. Four-celled conidia could be obtained only on host tissue.

The fungus was grown over a wide range of temperature and pH concentrations: i.e. 5°C, 20°C, 23°C, 25°C, 28°C, 32°C, wth (optimum 23°C), and pH 4.5 to 8 wth (optimum 5.5).

Among the carbon compounds, the fungus made best growth on maltose, although sucrose, glucose, fructose, lactose were also utilized fairly well, but mannitol and sorbitol were not suitable. Ammonium tartarate was the best utilized nitrogen compound followed by Sodium nitrate, Asparagin, Potassium nitrate and Ammonium phosphate, but with Ammonium sulphate and Ammonium nitrate the growth was very poor.

The fungus failed to infect *Trigonella foenum-graecum* (Methi), *Spinacea oleracea* (smooth leaf variety) *Chenopodium album*, and *Portulaca oleracea*.

Discussion. Report of *Heterosporium variabile* Cooke causing leaf spot on Spinach was made by Padwick (1945) from Srinagar (Kashmir-India) who also described the symptoms and morphology of the fungus. The isolate under study resembles *Heterosporium variabile* Cooke, in its morphological characters and symptoms described by Padwick.

Jacques (1941) made a comparative study of seven species of *Heterosporium* and showed that they fell roughly in three groups. His main basis of grouping appears to be the solitary or catenate form of conidial formation. The first group was closely related to the species of *Helminthosporium* (solitary conidia); the second sub-division formed an intermediate group connecting *Helminthosporium* (occasional appearance of solitary conidia) and *Cladosporium* (production of catenate spores); the third group resembled *Cladosporium* in the formation of catenate spores. He stated that *Heterosporium variabile* (belonging to the third group) may become so modified as to be taken for a typical *Cladosporium*. De Vries (1952) while studying in detail the morphology, taxonomy, biological and biochemical characters of the different species of *Cladosporium* and *Heterosporium variabile*, more or less confirmed the views of Jacques and placed the latter under *Cladosporium variabile* (Cooke) de Vries. The authors have accepted this position of the fungus for the present.

Summary

Spinach (*Spinacia oleracea* L.) suffers from a leaf spot disease caused by *Cladosporium variabile* (Cooke) De Varies (Syn. *Heterosporium variabile* Cooke), in the Kota district of Rajasthan. The disease is characterized by appearance of numerous dirty whitish water soaked, sharply defined, circular spots 1–3 mm. in diameter usually on the upper half of the leaves. The pathogenicity of the fungus has been established. It is highly specialised and does not attack any of the host plants tried, even smooth leaf variety of spinach. The infection takes place by means of the germ tube directly through cuticle.

Ammonium tartarate as organic source of nitrogen and maltose as carbon compound gave the best growth. The optimum temperature for the growth was 23 °C. The fungus can grow at 4.5 to 8 pH concentrations, optimum being 5.5 pH.

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ON THE OCCURRENCE OF PHYSIOLOGICAL STRAINS IN MYROTHECIUM RORIDUM

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Introduction. A survey of the fields and gardens in the vicinity of Jodhpur revealed that the leaf spots caused by *Myrothecium roridum* Tode Ex. Fr. on *Cyamopsis tetragonoloba*, as reported earlier by the author (Arya, 1956) also occur on *Phaseolus aconitifolius*, *P. radiatus*, *Vigna sinensis*, *Gossypium herbaceum*, *Luffa acutangula*, *Lagenaria vulgaris* and *Impatiens balsamina*. A comparative study of the isolates from these hosts was therefore carried out in order to determine their identity as well as their relationship to one another with particular reference to *Myrothecium roridum*, isolated earlier from *Cyamopsis tetragonoloba*.

The symptoms of the disease on these hosts were more or less similar to those described by Arya (1956) on *Cyamopsis tetragonoloba*. However in some of them like *Phaseolus aconitifolius* and *P. radiatus* only dark coloured, irregular spots were formed which did not show any regular circular type of zonations.

A chlorosis around the spots was a common symptom noticed in all the hosts. In severe cases of infection, the entire infected leaf sometimes became chlorotic leading to its defoliation.

The fungus was isolated from the infected tissues of the host by the normal methods and incubated at 30°C. All the isolates were further purified by obtaining single spore cultures.

Experimental. Comparative pathological studies of the isolates have been carried out at different stages of the growth of the plants.

Infection of seedlings and adult plants: Cotyledonary leaves of seedlings; and leaves and pods of adult plants were inoculated by smearing them with conidia of different isolates. Inoculated plants were incubated in moist chambers at saturated humidity for twenty four hours. The estimation of the intensity of infection has been expressed by the symbols (3) if the lesions formed were large and coalescent covering large areas on the leaf blade or the pods; by (2) if the lesions were non-coalescent and not very large and by (1) only if the lesions were as small scattered specks. The treatment was repeated three times before confirming the type of reaction obtained. The data are presented in table 1. The data given in this table show that all the isolates are able to infect all the hosts, but the intensity of their infectivity varies. Accordingly, the isolates can be distinctly grouped into five types (1) A and D, (2) B and C, (3) E, (4) F and G and (5) H.

TABLE 1. Results of inoculation of different host leaves with various isolates.

Name of the host	Intensity of infection							
	ISOLATES							
	A	B	C	D	E	F	G	H
A. *Cyamopsis tetragonoloba*	(3)	(2)	(2)	(3)	(1)	(2)	(2)	(3)
B. *Phaseolus aconitifolius*	(1)	(3)	(3)	(1)	(3)	(1)	(1)	(1)
C. *Phaseolus radiatus*	(1)	(3)	(3)	(1)	(3)	(1)	(1)	(1)
D. *Vigna sinensis*	(3)	(1)	(2)	(3)	(2)	(2)	(2)	(3)
E. *Gossypium herbaceum*	(2)	(2)	(2)	(2)	(3)	(1)	(1)	(1)
F. *Luffa acutangula*	(2)	(1)	(1)	(2)	(1)	(3)	(3)	(2)
G. *Lagenaria vulgaris*	(2)	(1)	(1)	(2)	(1)	(3)	(3)	(2)
H. *Impatiens balsamina*	(3)	(1)	(1)	(3)	(1)	(2)	(2)	(3)

NB. A,B,C,D,E,F,G,H, refer to the isolates from the respective hosts in column 1.

MORPHOLOGICAL CHARACTERS. A comparative study of the fungus morphology of the various isolates has shown that they do not show any significant variation among themselves. The general characters of the mycelium, conidiophores and conidia remain the same as described earlier (Arya, 1956). However, some minor fluctuations in the measurements of the conidia of the various isolates have been observed. The measurements are recorded in table 2. Preston (1943), while examining isolates of *Myrothecium roridum* from different host plants, also reported such variations in the measurements of the conidia.

TABLE 2. Measurements of the conidia of various isolates

Name of the isolate	Measurements of the Conidia
A.	5.0 – 7.5 X 1.5 – 2.0 μ; average 6.5 X 1.7 μ.
B.	6.0 – 8.5 X 1.5 – 2.5 μ; average 7.0 X 1.8 μ.
C.	6.0 – 8.5 X 1.5 – 2.5 μ; average 7.5 X 2.0 μ.
D.	6.5 – 9.5 X 1.5 – 3.0 μ; average 7.5 X 2.5 μ.
E.	7.5 – 11.5 X 1.5 – 3.0 μ; average 8.5 X 2.5 μ.
F.	6.5 – 8.5 X 1.5 – 3.0 μ; average 7.0 X 2.5 μ.
G.	7.0 – 9.0 X 1.5 – 3.0 μ; average 8.0 X 2.5 μ.
H.	5.5 – 8.0 X 1.5 – 2.5 μ; average 6.5 X 2.0 μ.

CULTURAL CHARACTERS. A comparative study of the growth and sporulation of all the isolates was carried out by growing them on potato dextrose agar medium which, as observed earlier, gave satisfactory growth

of the fungus. The rate of growth has been measured in terms of the area of the developed colony. The data are presented in table 3.

TABLE 3. The rate of growth of the isolates on P.D.A. at 27°C.

Name of the isolate	Growth in sq. mm. in 3 days	8 days	15 days	Remarks
A.	154	1386	3630	
B.	140	1125	3132	Colony dark
C.	140	1128	3120	green with fructi-
D.	154	1385	3630	fications in circular
E.	180	1450	4010	zones.
F.	200	1495	4215	
G.	200	1495	4215	
H.	125	1100	2810	

The data given in table 3 show no difference in colony character of the isolates, but the distinction in the rate of their growth is quite apparent.

GROWTH OF THE ISOLATES ON DIFFERENT NUTRITIONAL MEDIA; An experiment was also set up to study the rate of growth and sporulation of all the isolates on a variety of artificial solid media at a constant temperature of 27°C. The general cultural characters of all the isolates were more or less similar i.e. a week old cultures started throwing out greenish black coloured synnemata in regular circular zonations. A satisfactory surface growth, with copious sporulation was obtained on potato dextrose agar (2% dextrose), oat meal agar (without dextrose), oat meal agar (with 5% dextrose), Czapek's agar and Richards agar. On corn meal agar, however, the mycelial growth was very thick, but sporulation was poor. The growth, on oat meal agar, both with 5.0 per cent dextrose and without it, was more fluffy with comparatively less sporulation. The isolates attained the highest rate of growth in oat meal agar with 5.0 per cent dextrose. There was some variation in the colour reaction produced by the isolates on corn meal agar. The isolate E from cotton gave bright yellow colour to the medium. The isolates F and G produced brown colour in the medium. The rest of the isolates, A, B, C, D, and H had practically no effect on the normal colour of the medium.

The growth of the colony was calculated in terms of its area. The behaviour of the isolates here also followed the earlier mentioned pattern i.e. they can be grouped into five distinct types or strains.

CONCLUSION AND SUMMARY

Isolates of *Myrothecium roridum* from eight different host plants growing in the vicinity of Jodhpur do not show any host specificity but could be made out clearly, based on the degree of infection.

Morphological studies of the isolates show no significant difference, except minor variations in the measurements of the conidia.

Study of the cultural characters of the isolates on potato dextrose agar and other nutritional media clearly show variation in the rate of growth of the isolates on the basis of which these can be grouped into 5 types. Influence of temperature and pH further strengthen the view.

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EFFICACY OF DIFFERENT FUNGICIDES II FIELD TRIALS IN RELATION TO WHEAT RUSTS

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Twenty nine million acres of wheat crop in India is subject to attack by rusts year after year resulting in reduced yields. According to Vasudeva (1954) the annual loss due to wheat rusts is in the neighbourhood of 49 million rupees and reduction in grain yield varies from 10 to 50 percent depending upon the variety, stage at which the infection takes place and the intensity of rust attack. In epidemic years, however, the loss is much heavier. In 1947 the loss in our country was estimated at two million tons of wheat which is nearly one fifth of the total production of undivided India (Mehta 1950). Some cultivators did not raise enough crop even for seed purposes.

Undoubtedly the most effective method of control is the cultivation of resistant variety but the method is arduous and involves long range investigations. The chief drawback in this method of control has been the appearance of new races from time to time, with the result that a new variety which has been produced after years of work has to be discarded so that breeding for resistance is a continuous process and is, therefore, a battle between the scientist and the fungus. The question is who would out-pace the other. Success in this respect can only be achieved if we can keep ahead of the fungus in the breeding programme. In U.S.A. wheat breeding for rust resistance received a setback with the discovery of race 15B. Chemical method of control, therefore, has received considerable attention in different wheat growing countries. While we in India are engaged on breeding for resistance it is at the same time necessary to look for other methods of control. With the present state of our knowledge, the chemical method of control is no doubt very costly but in the years of epidemics it is perhaps the only means by which at least the areas meant for seed production can be protected from the ravages of this serious disease. With this object in view an attempt was made to test the comparative efficacy of some of the organic fungicides, results of which are reported herein.

Material and Methods. Fungicidal trials were conducted for the control of brown and black rusts of wheat with nine fungicides (Dithane Z-78, Parzate liquid, Dithane M-22, Fermate, Zerlate. Flit 406, Ultra sulphur, Sulphur and Merbam). Wheat variety C 518 which is susceptible to rusts was sown in the middle of November in plots of 6 feet x 20 feet. Four replications were kept for the control as well as for each treatment. The experimental plots were given the first application of fungicides on Ist February followed by three more sprays at fortnightly intervals. Sulphur was, however, dusted in the early hours of the morning when leaves were wet with dew. The sprayings were done at the rate of 100 gallons of spray per acre with the help of foot sprayers, and sulphur was dusted at the rate of 15 lbs. per acre with hand rotary duster.

It was felt that the comparative efficacy of fungicides should be tested under epidemic conditions. For this purpose the initial inoculum of race 15, 21, 24, 34, 40, 42, 42-B and 117 which include some of the most prevalent races of *Puccinia graminis tritici* during the last ten years, was obtained from the Mycological sub-station Simla, where all the type cultures of the Indian races of the rusts are being maintained. The inoculum of each race was multiplied separately on seedlings of *Agra local* variety of wheat under glass house conditions.

Two days after the first fungicidal spray, the uredospores of the above mentioned races mixed with french chalk (1 : 100) were dusted on the plants in the experimental plots which were kept under high humidity for four hours before and thirty six hours after inoculations with the help of tents of thick "Dasooti" cloth. By this time natural infection of brown rust (*Puccinia triticina*) had already started appearing, therefore, the crop was not inoculated with this rust. A close watch was kept on the development of the rusts and final data regarding the incidence of brown rust was recorded in the middle of March and that of black rust in the first week of April on the basis of modified Cobb's scale (Melchers and Parker 1922) when the intensity of these rusts was at their maximum.

The experiment was repeated for two years. The criteria which were used to evaluate the effectiveness of fungicides are (a) percentage of rust infection, (b) one thousand grain weight, (c) yield of treated plants in maunds per acre. The relevant data in this respect are summarized in table I.

The results in the table indicate that in 1957–58 infection of brown and black rusts was only in traces in plots sprayed with Parzate liquid plus zinc sulphate, as compared to light of brown rust and light to medium of black rust in control and other plots treated with various fungicides. The yield in the plots sprayed with Parzate liquid was 28.6% higher than that in the untreated controls. In 1958-59 incidence of black rust was in traces and that of brown rust from traces to light in the plots sprayed with Parzate liquid. In controls brown rust varied from medium to heavy while black rust was heavy in all the replicates. The yield from plots sprayed with Parzate liquid was 69.8% more than that in controls.

Observations made during both the years show that the intensity of rusts in the plots sprayed with Parzate liquid (nabam) was reduced to traces and that the yield from such plots was higher as compared to the untreated controls. The grain in the treated plots was also normal plump against shrivelled one from the control plots. Forsyth and Peturson (1958) working on the field evaluation of fungicides for the control of stem and leaf rusts of wheat also reported that spraying with disodium ethylenebisdithiocarbamate plus zinc sulphate could effectively control the rusts and that sulphur dusting was costlier than spraying with this fungicide in Canada.

Summary

Nine fungicides, Dithane Z-78, Parzate liquid, Dithane M-22, Fermate, Zerlate, Flit 406, Ultra Sulphur, Sulphur and Merbam were tried in the field

TABLE I. The effect of fungicides on the intensity of brown and black rusts and grain yield of wheat in the field.

S. No.	Fungicide	Active ingredient	Dose lb/ acre	1957–58				1958–59			
				Rust infection		1000 kernel wt. in gms.	Yield per acre (in mds.)	Rust infection		1000 kernel wt. in gms.	Yield per acre (in mds.)
				Brown	Black			Brown	Black		
1.	Dithane Z-78	65% Zinc ethylenebis (dithiocarbamate)	1.5	L	L to M	34.5	17.30	M	H	32.1	17.55
2.	Parzate liquid plus zinc sulphate.	22% Disodium ethylenebis (dithiocarbamate)	½ gal. + ¾ lb.	Tr.	Tr.	44.1	22.60	Tr. to L	Tr.	43.4	26.66
3.	Dithane M-22	80% Manganese ethylenebis (dithiocarbamate)	1.5	L	L	39.7	19.92	L	Tr. to L	38.1	24.30
4.	Fermate	76% Ferric dimethyl-dithiocarbamate	2	L	L to M	39.2	19.99	M	M to H	31.7	18.74
5.	Zerlate	76% Zinc dimethyl-dithiocarbamate	2	L	L to M	39.1	19.92	M to H	H	32.5	18.01
6.	Flit 406	50% n–(trichloro methyl-mercapto)–4–cyclohe-xene–1, 2–dicarboximide	2	L	L to M	34.2	16.61	M to H	H	27.9	15.82
7.	Merbam	10% phenylmercury dimethyl-dithiocarbamate	2	L	L to M	34.3	16.61	L to H	H	31.1	16.36
8.	Ultra-sulphur	sluphur	2	L	L to M	36.4	18.47	L to M	H	33.6	17.36
9.	Sulphur	sulphur	15	L	L to M	35.8	17.16	L to M	H	36.9	21.36
10.	Control.	—	—	L	L to M	34.4	17.57	M to H	H	25.7	15.70

Note:— Tr. denotes 0–10%; L, 11–25%; M, 26–40% and H, 41–65% infection.

for the control of black rust of wheat (*Puccinia graminis tritici*). Four sprayings of Parzate liquid (disodium ethylenebisdithiocarbamate) plus zinc sulphate at fortnightly intervals beginning in the first week of February reduced the rust infection from heavy to traces with corresponding increase in the yield.

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A BACTERIAL DISEASE OF CICER ARIETINUM L.

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In the course of our studies on the influence of micro-organisms on seed germination it was observed that the seeds of *Cicer arietinum* L. (Bengal gram) were severely affected by a bacterial disease which caused post-emergence rot of the seedlings. The affected seed on germination showed water-soaked lesions on the radicle. These lesions soon turned dark brown accompanied by soft-rot of the tissues resulting in the wilting of seedling within 3 or 4 days. The bacterium was isolated and studied for its pathogenicity, host range and systematic position and the results are reported here.

The seeds were surface-sterilized with 0.1 per cent mercuric chloride solution, washed thoroughly with sterile distilled water and plated on nutrient agar media. The bacterial colonies developing from inside the tissues were isolated and brought into pure culture by the single colony method. The culture was then tested on the healthy seeds by soaking them in the bacterial suspension for an hour and sowing in sterile agar media, on moist filter paper in Petri dishes or in the soil in pots. Though there was only slight reduction in the germination percentage, typical post-emergence rotting symptoms could be observed in all the cases within five days after sowing (Fig. 1). The percentage infection was 80 in the agar plates, 92 on filter papers and 21 in the soil. The bacterium was reisolated from the infected seedlings and was found to be identical with the original isolate.

The bacterium was studied for its morphological, cultural and nutritional characters. Colonies on nutrient agar were smooth, shining, convex, dull yellow coloured and slow growing with somewhat irregular or lobed margin. The bacteria were short rods with blunt ends, Gram-negative, capsulated, non-acid-fast, non-sporing, motile with single polar flagellum, measuring 1.0 to 1.8 x 0.6 to 1.0 μ. Growth on potato plugs honey coloured, slimy; in nutrient broth, turbid with sedimentation; slow liquefaction of gelatin, rapid hydrolysis of starch; milk peptonized; non-lypolytic; ammonia and hydrogen sulphide produced; nitrate not reduced; M. R. and V. P. tests negative. Mannose, lactose, raffinose, sucrose, galactose, levulose and starch utilized with acid formation and no gas production, while maltose, dextrose and salicin without acid and the gas production; mannitol and sorbitol not utiltized as a carbon source. L–asparagine, L–glutamic acid, DL–threonine, DL–histidine hydro-chloride, L–leucine, DL–valine, L–cystine, creatine, urea, uranium nitrate, ammonium oxalate, ammonium hydrogen phosphate, ammonium sulphate, ammonium chloride, potassium nitrate and sodium nitrate utilized as nitrogen sources.

The bacterium was further studied for its infectivity on the seeds of the following plant species: *Cajanus indicus* Spreng., *Vigna catjang* Endl., *Sesbania speciosa* Taub., *Phaseolus mungo* L., *P. aureus*, Roxb., *Crotalaria juncea* L., *Arachis hypogea* L., *Cassia occidentalis* L., *Trigonella foenum-graecum* L., *Paspalum scrobiculatum* L., *Sorghum vulgare* Pers., *Setaria italica* Beauv. and *Eleucine coracana* Gaertn., besides *Cicer arietinum*. It was found that, except in *C. arietinum*, in no case there was either reduction in the germination percentage or post-emergence rotting.

The isolate was also inoculated on the leaves of one month old plants of the following species grown in the pot culture house: *Cajanus indicus*, *Vigna catjang*, *Sesbania speciosa*, *Arachis hypogea*, *Phaseolus mungo*, *P. aureus*, *Crotalaria juncea*, *Trigonella foenum-graecum*, *Cassia occidentalis* and *Cicer arietinum*. The inoculations were made by transfering 48 hour cultures of the bacterium from nutrient agar slants to the leaves after wounding the surface with fine needles. The inoculum was kept moist by placing a piece of sterile wet cotton wool over it, soon after inoculation. Highly humid conditions were provided by placing the plants inside humid chambers made of alkathene sheets. The bacterium was found to infect only *C. arietinum* and *Cassia occidentalis* and not the others. On *C. arietinum* the infection symptoms were first observed after four days as minute water-soaked lesions, which very soon developed into dark brown spots of 1 to 2 mm. in diameter with chlorotic haloes. As the disease advanced the spots coalesced causing severe chlorosis of the leaflet and typical leaf blight symptoms (Fig. 2). On *C. occidentalis* dark brown spots, 3 to 5 mm. in diameter, with irregular margin and distinct chlorotic haloes were observed. These spots coalesced and caused severe chlorosis of the leaves (Fig. 3). The isolate was also found to infect the petiole causing dark brown linear lesions which caused severe defoliation. The bacterium was reisolated from the infected leaves of *C. arietinum* and *C. occidentalis* and found identical with the original.

On the basis of morphological, cultural and physiological properties and its pathogenicity the bacterium is identified as *Xanthomonas cassiae* Kulkarni *et al*. *X. cassiae* was isolated from *Cassia tora* L. causing leaf spot and was found to be carried in the seed (Kulkarni *et al* 1951). The bacterium under study was also found to be carried in the seeds of *C. arietinum* causing post-emergence rot. It also infects a related species of *Cassia*, viz., *C. occidentalis* causing leaf spots identical with those reported on *C. tora*. Furthermore, the bacterium is identical in most of its morphological, cultural and physiological properties with those of *X. cassiae* on *C. tora*, except in utilizing arabinose and glycerol. The only other record of a bacterial disease on *C. arietinum* seems to be *Corynebacterium fascians* (Tilford) Dowson, made by Jacobs and Mohanty (1951). The bacterium under study is distinct from *C. fascians* and is the first record of a *Xanthomonas* on this host.

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Fig. 1. Bacterial soft-rot of the radicles of *Cicer arietinum* L.

Fig. 2. Leaf spots and blight of *Cicer arietinum* L., caused by the bacterium on artificial inoculation.

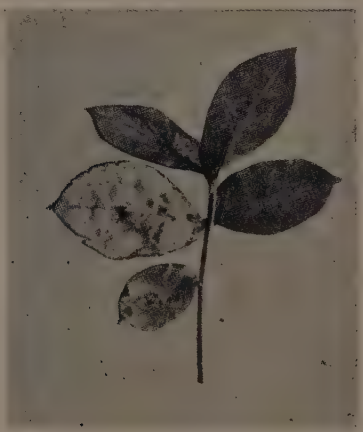

Fig. 3. Leaf spots and chlorosis caused by the bacterium on *Cassia occidentalis* L. on artificial inoculation.

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NOTES ON MISCELLANEOUS INDIAN FUNGI-VI

R. L. Munjal, B. L. Chona and J. N. Kapoor

(Accepted for publication December 15, 1959)

The present paper is in continuation of the series, five parts of which have been published in the earlier volumes of Indian Phytopathology.* In this note, we have given account of 18 fungi, of which 3 are new species and 16 new records for India. The specimens have been deposited in Herb. Crypt. Ind. Orient., I. A. R. I., New Delhi and indicated in the text under the H. C. I. O. numbers.

95. *Didymella clavulata* Ellis, in Amer. Nat., p318, 1883; Saccardo in Syll. Fung. **9**:666, 1891.

On fallen leaves of *Quercus incana* Roxb. (Fagaceae), Mussoorie, U.P., 12–10–1955 (J. N. Kapoor), H. C. I. O. No. 24188.

Patches of black dotlike perithecia occur on both the leaf surfaces. Perithecia are globose and measure 105–130 μ in diameter; asci are oblong to cylindrical, densely parahypsate, 35–50 x 4–5 μ in size; ascospores are oblong to fusoid, constricted at the septum and measure 6–7 x 2–3 μ in size.

96. *Microthyrium quercus* Fuckl., in Symb. Myc. p98, 1869; Saccardo in Syll. Fung. **2** : 663, 1883.

On fallen leaves of *Quercus incana* Roxb. (Fagaceae), Mussoorie, U. P., 12–10–1955 (J. N. Kapoor), H. C. I. O. No. 24187.

Old decaying leaves show densely gregarious patches of black, superficial, dimidiate ascocarps having radiate scutellum, 130–210 μ in diameter; asci are clavate, aparaphysate and 35–40 x 9–11 μ in size; ascospores are bicelled, fusoid, one end acute and the other obtuse and rounded, 7–11 x 3–4 μ in size.

97. *Erysiphe cichoracearum* DC., in Flora Franc. **2** : 274, 1805.

On leaves and stems of *Sonchus arvensis* L. (Compositae), Karnal, Punjab, 10–5–1956, (H. S. Sohi), H. C. I. O. No. 24186.

Cleistothecia produced abundantly both on stem and leaves, measuring 80–110 μ in diameter; appendages are light brown and flexuous; asci are 10–20 in number, ovate to obovate in shape and measure 50–65 x 25–35 μ; ascospores 2, sometimes 3, ovate and measure 14–21 x 12–14 μ.

* Ind. Phytopath., **3** : 105–116, 1950; **8** : 184–198, 1955; **9** : 53–56, 1956; **9** : 125–136, 1956; **10** : 148–156, 1957.

98. *Mycosphaerella grevilleae* sp. nov.

Perithecia dispersa in area discolorata ad apices foliorum, innata carbonaceo-nigra, globosa, ostiolo lato, diametientia 40–70 μ; asci paraphysati, compacti, clavati, octospori, magnitud. 20–25 x 5–8 μ; ascosporae hyalinae, bicellulatae, biseriatae, oblongae vel ellipticae, apicibus rotundatis, magnitud. 7-9 x 2–3 μ.

In foliis viventibus *Grevilleae robustae* A. Cunn. (Proteaceae), ad Saharanpur in region U. P. die 6 octobris anni 1955 a J. N. Kapoor. H. C. I. O. No. 26086, Typus.

Perithecia are scattered in the discoloured areas at the leaf tips, they are innate, black, carbonaceous, globose and measure 40-70 μ in diameter; asci aparaphysate compact, clavate, 8–spored and measure 20–25 x 5–8 μ in size; ascospores hyaline, biseriate, bicelled, oblong to elliptic, ends rounded and measure 7-9 x 2–3 μ.

On living leaves of *Grevillea robusta* A. Cunn. (Proteaceae), Saharanpur, U. P., 6–10–1955 (J. N. Kapoor), H. C. I. O. No. 26086, Type.

99. *Mycosphaerella donacis* sp. nov.

Maculae foliorum amphigenae, plus minusve ellipticae, straminae, marginibus purpurascentibus vel rubris, qui tamen postea evanescent, nonnumquam confluentes, magnitud. 2-10 x 1–2 mm. ; perithecia dispersa in maculis, sed cum folia desiccantur etiam extra maculas apparent, fusce brunnea, innata postea erumpentia, diametientia 40–75 μ ; asci paraphysati, clavati vel cylindrici, octospori, magnitud. 21–35 x 8–11 μ; ascosporae biseriatae, hyalinae, oblongae, bicellulatae, apicibus rotundatis, magnitud. 7–11 x 2–3 μ.

In foliis viventibus *Arundinis donacis* L. (Gramineae) ad Raiwala Dehradun, in regione U. P. die 8 octobris anni 1955 a J. N. Kapoor. H. C. I. O. No. 26081, Typus.

Leaf spots amphigenous, more or less elliptic, straw coloured with purple red border which may fade later, sometimes confluent and measure 2–10 x 1–2 mm. in size; perithecia scattered in the spot but appear outside also when the leaf tissue is dead, dark brown, innate later erumpent and measure 40–75 μ in diameter; asci aparaphysate, clavate to cylindric, 8-spored and measure 21-35 x 8–11 μ; ascospores biseriate, hyaline oblong to elliptic, ends rounded and measure 7–11 x 2–3 μ.

On living leaves of *Arundo donax* L. (Gramineae), Raiwala, Dehradun, U. P., 8-10-1955, (J. N. Kapoor), H. C. I. O. No. 26081. Type.

100. *Microstroma pongamiae* sp. nov.

Maculae hypophyllae, indistinctae, albidae vel cremeae, ambitu irregulares, nervis limitatae, 2–5 mm. diam., numerosae ut plurimum singulae, raro confluentes, atque folium totum luteotum reddentes. Mycelium vegetativum es stricte parasiticum in foliis. Fructifications

constant e fasciculis conidiophororum qui totam maculam operiri possunt atque sunt albidi et pulverulenti. Conidiophori clavati, rotundati vel applanati ad apicem, angustati vel fastigati infra, supportantes sterigmata terna vel quaterna, acuta, filiformia ad apicem. Conidiophori unicellulati, hyalini, 36–50 μ longi, 3–4 μ lati, ad partem latissimum 5–6 μ, ad basin 2–3 μ. Sterigmata 4–5 x 1 μ, hyalina, unicellulata, sigulariter et acrogene producunt conidia. Conidia hyalina, unicellulata, ellipitica, rotundata ad utrumque apicem, paulo latiora ad medium, 6–7 x 2-3 μ (3–4 μ ad medium latissimum).

In foliis viventibus *Pongamiae glabrae* Vent. (Leguminoseae), in area mycologica ad I. A. R. I., New Delhi, die 10 Januarii anni 1948. (R. L. Munjal) H. C. I. O. No. 26146, Typus.

Spots hypophyllous, indistinct, white to cream coloured, irregular in outline, delimited by veins, 2—5 mm. in diameter, numerous, mostly isolated rarely confluent giving a yellowish appearance to the entire leaf. The vegetative mycelium is strictly parasitic in leaf. The fructifications consist of group of conidiophores which may cover the entire spot and are white and powdery. The conidiophores are club shaped, rounded or flattened at the apex, narrowed or tapering below, bearing 3-5 pointed thread like sterigmata at the tip. The conidiophores are singlecelled, hyaline measure 36-50 μ long and 3-4 μ broad at the broadeist point 5-6 μ and 2-3 μ at the base. The sterigmata hyaline, single celled, measure 4-5 x 1 μ, and bear conidia acrogenously singly. The conidia are hyaline, single celled, elliptic, both ends rounded, slightly broader in the middle, 6-7 x 2-3 μ (3-4 μ in the middle, at the broadest point).

On living leaves of *Pongamia glabra* Vent. (Leguminoseae). Mycological area, I. A. R. I. New Delhi, 10-1-1948. (R. L. Munjal), H. C. I. O. No. 26146, Type.

101. *Graphium aeruginosum* (Desm.) Sacc., in Syll. Fung. **6** : 618, 1888.

On rotting bamboo stumps, mycological area, I. A. R. I., New Delhi, 28-7-1956 (R. L. Munjal), H. C. I. O. No. 25580.

The fungus was found growing gregariously on rotting bamboo stumps in a shady and humid place. It was very conspicuous due to its bright salmon coloured conidial heads. Synnemata are erect, solitary or in bunches of 2-3, cylindrical, 1-1.5 mm. long; conidiophores are simple and hyaline bearing terminal conidia; conidia produced in abundance and embeded in mucous, hyaline but light ochraceous salmon in mass, ovate to globose and measure 3-4 x 2-3 μ .

102. *Eutypella stellulata* (Fr.) Sacc., in Syll. Fung. **1** : 149, 1882.

On dead stem of *Indigofera arrecta* Hochst. (Leguminoseae), Pusa, Bihar, 18-9-1909 (A. H. Khan), H. C. I. O. No. 24196.

Stroma black, sunk deep in the bark; perithecia 4-6 in single stroma, subglobose or angular due to mutual pressure, 300-450 x 180-300 μ without neck, necks converging, about 150-200 μ long; asci cylindrical

clavate, 30-40 x 5-8 μ, with a long hyaline stipe, 8-spored; ascospores irregularly biseriate, allantoid, unicellular, subhyaline, 8-11 x 2-3 μ.

This fungus has earlier been recorded on *Ulmus* and several other hosts from outside India and the description exactly fits the original as given by Saccardo. Although this specimen was collected some fifty years back, it is still in good condition.

103. *Eutypella paradisiaca* Speg. in F. Arg. Pug. IV : **125,** Sacc. in Syll. Fung. **1** : 157, 1882.

On dead stem of *Dalbergia sissoo* Roxb. (Leguminoseae), Pusa, Bihar, 14-5-1906 (A. H. Khan), H. C. I. O. No. 24197.

Stroma subspherical, black, buried deep in the bark; perithecia 3-6 in stroma, subglobose or elongated due to mutual pressure, 250-300 μ in diameter, necks converging and protruding out of stroma; asci clavate, 8-spored with a long hyaline stipe, 18-30 x 4-6 μ in size; ascospores subhyaline, biseriate, allantoid and measure 9-11 x 2-4 μ. This material is also very old but is still in good condition.

104. *Balansia oryzae* Naras. & Thirum., in Curr. Sci. **12** : 276, 1943. =*Ephelis oryzae* Syd., Ann. myc., **12** : 489, 1914. (Status imperfectus)

On panicles of *Ottochloa nodosa* Dandy (Gramineae), locality, date and collector not known. H. C. I. O. No. 24219.

Stroma surrounding the axis of the inflorescence is solid and dark coloured with an olivaceous tinge; pycnidia are embedded in the stroma, elongated to circular, confluent; conidia filiform, hyaline and measure 15-40 x 1.5 μ.

105. *Ustilaginoidea virens* (Cke.) Tak., in Bot. Mag. Tokyo, **10** : 16—20, 1896.

On male inflorescence of *zea mays* L. (Gramineae), Kulu Valley, 15-9-1956. (V. S. Sharma). H. C. I. O. No. 24219.

The specimen has the appearance of the common smut. The surface of the sclerotium is much roughened, olive green to almost black in colour. The spores are 4-7 μ in diameter. This fungus has earlier been recorded on this host, from Louisiana, U. S. A. by Haskell and Diehl (Phytopath. **19** : 589, 1929).

106. *Ascochyta rhei* E. & E., in Proceed. Acad. S. N. Philad., p.160, 1893.

On leaves of *Rheum rhaponticum* L. (Polygonaceae), Darjeeling, W. Bengal, 29-8-1956 (S. P. Raychoudhury). H. C. I. O. No. 25232.

Spots concentric, purple, centre of the spot becomes brittle and cracks; pycnidia epiphyllous, dark brown; conidia fusoid-ovate, bicelled, constricted at the septum, 6-10 x 3-4 μ.

107. *Aecidium verbenae* Speg., in Anal. Soc. Argent. **9** : 174, 1880.

On *Lantana indica* Roxb. (Verbenaceae), Ridge area, Delhi (A. Khan) date of collection not known. H. C. I. O. No. 25422.

Pycnia hypophyllous, in small groups, on brownish spots about 3 mm. in diameter; aecia hypophyllous, cupulate; aeciospores rounded, 14-21 μ in diameter, wall colourless, thin, inconspicuously verrucose.

108. *Ciliochorella mangiferae* Syd., in Ann. myc. **33** : 62-64, 1935.

On fallen leaves of *Quercus incana* Roxb. (Fagaceae), 10-10-1955 (J. N. Kapoor), H. C. I. O. No. 25899.

The specimen was compared with the type of this species and was found to be identical.

109. *Pestalotia breviseta* Sacc., Mich. **1**. p. 92,; Fungi italici, Tab 34, 1877.

On living leaves of *Pyrus pashia* Ham. (Rosaceae), Mussoorie, U. P., (J. N. Kapoor), H. C. I. O. No. 25923.

Acervuli minute, studded in round to a little irregular greyish leaf spot; conidia 20-25 x 7-10 μ and setae 8-10 x 1 μ.

110. *Pseudoperonospora cannabina* (Otth) Hoerner, in J. Wash. Acad. Sci. **30** : 133, 1940.

On leaves of *Cannabis sativa* L. (Moraceae), Sewage area, I. A. R. I., New Delhi, 19-1-1957 (Ved Prakash & Gian Singh), H. C. I. O. No. 25923.

The fungus forms grey coloured thick, downy growth in irregular patches on the under surface of the leaf. There are corresponding chlorotic patches on the upper leaf surface.

111. *Didymosporium culmigenum* Sacc. in Fungi Italici, Tab. 1093, 1881; Syll. Fung. **3** : 763, 1884.

On leaves and culms of grass , probably a *Saccharum* sp. (Gramineae). Gangtok, Sikkim, 9-4-57 (J. N. Kapoor), H. C. I. O. No. 25441.

Acervuli black, dotlike; conidia dark brown fusoid, one septate, constricted at the septum, ends pointed, 12-16 x 5-7 μ.

112. *Rhinotrichum tenellum* Berk. & Curt., in Grev. **3** : 109, 1895.
Syn. *Oidium tenellum* (Berk. & Curt.) Linder, in Lloydia **5** : 173, 1942.

On earheads of *Sorghum vulgare* (Gramineae), botanical area, I. A. R. I. New Delhi, September 1957 (Amar Singh), H. C. I. O. No. 25455.

The infected earheads are conspicuous due to the dense greyish-white growth of the fungus. The conidiophores are erect or suberect, simple

or branched, septate; conidia bearing cells enlarged obclavate having sterigmata which are very conspicuous; conidia hyaline, ovate-ellipsoid, 10-22 x 7-15 μ.

Rao, Salaam and Thirumalachar have described a new genus *Dicksonomyces*, believed to belong to Peronosporaceae (Mycologia **48** : 860-864, 1956). The type specimen of this genus was examined and its conidial stage was found to be identical, with *Rhinotrichum tenellum* Berk. & Curt. It appears that the oospores found by the authors belong to *Sclerospora*, which is very common on this host.

ACKNOWLEDGMENTS. We wish to record our grateful thanks to Dr. R. S. Vasudeva, Head of the Division of Mycology and Plant Pathology, Indian Agricultural Research Institute, New Delhi, for his keen interest, helpful criticism and encouragement. Our sincere thanks are also due to Rev. Father Dr. H. Santapau, St. Xaviers College, Bombay, for rendering latin diagnosis of the new species.

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EXPLANATION OF PLATES

Fig. 1. *Mycosphaerella grevilleae* (Semidiagrammatic)
Fig. 2. *Mycosphaerella donacis* (,,)
Fig. 3. *Microstroma pongamiae*
(a) Conidiophore
(b) Conidia

Figure 1

Fig. 2.

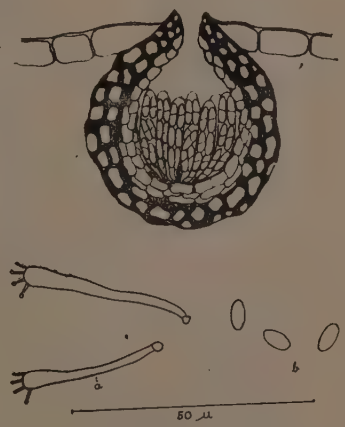

Figure 3

Phytopathological Notes

Studies on the Fungicidal control of Rice Blast. II. Determination of the Tenacity of Fungicides found to be effective against Piricularia oryzae.—D. V. W. Abeygunawardena and J. W. L. Peiris Retention and tenacity of the spray deposit are important factors which determine the field performance of any protective fungicide used in plant disease control. In selecting fungicides for the control of rice blast, particularly under conditions of heavy rainfall, careful consideration need be given to these requirements.

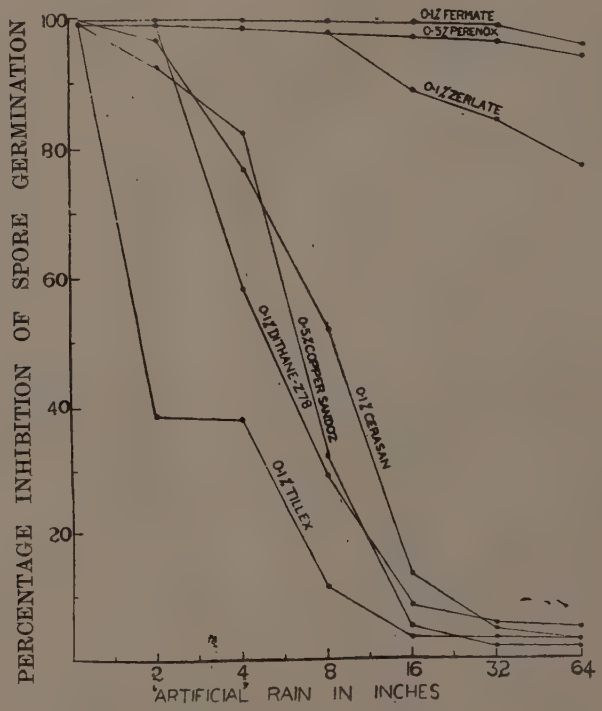

Fig. 1. Showing tenacity of different fungicides.

'Artificial' rain was produced in a wooden chamber using a stationary horizontal sprayer fitted with a rose type nozzle. Tap water was atomised continuously at a pressure of 24 pounds per square inch. Deposits of fungicides were obtained on glass slides by the method described by

Abeygunawardena and Peiris[1]; the slides were placed at a distance of two feet away from the sprayer and subjected to 'artificial' rain for varying intervals. After this leaching process the slides were dried and the residues of fungicides estimated for their fungistatic efficacy by the biological assay method.

Inhibition of spore germination was plotted against the quantity of 'artificial' rain, the rate of loss of fungistatic activity of the different materials when subjected to weathering for varying periods of time is shown in Fig. 1. The results for each fungicide constitute the mean from three experiments.

Tenacity of fungicides vary considerably from one formulation to another. Of the two copper fungicides tested, both containing cuprous oxide as the copper base, Copper Sandoz leached very rapidly and its efficacy was reduced to less than 50% when weathered with 8 inches of rain; Perenox, on the contrary was highly resistant to weathering and its efficacy was only slightly impaired even when subjected to rainfall as heavy as 64 inches. Among the carbamate fungicides tested Fermate proved to be the most tenacious. Dithane Z-78 was rapidly leached with 4 inches of rain whilst Zerlate remained more resistant to weathering.

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Ceylon

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[1] Abeygunawardena, D. V. W. and Peiris, J. W. L. (1958): Studies on the fungicidal control of Rice Blast. 1. The fungistatic efficacy of certain organic and inorganic fungicides on *Piricularia oryzae* (In press). *Indian Phytopath.*

A new Seedling Blight of Phaseolus mungo L. and P. aureus Roxb. G. Rangaswami and N. N. Prasad. During February-March, 1958 and also during the same period in 1959 a severe seedling blight disease of *Phaseolus mungo* L. (back gram or *urd*) and *P. aureus* Roxb. (green gram or *mungbean*) was noticed in the fields near Annamalainagar. Similar blight disease was also found to cause hundred per cent wilting of the seedlings raised in pots under green house conditions. Microscopic examination of the diseased plants from the fields and from the pots revealed the association of a fungus similar to, but not identical with, the ones recently reported on brinjal by Pawar and Patel (1957)[1] and on mesta by Gosh and Mukerjı (1958)[2].

The disease mainly manifests itself on the seedlings with two to six leaves, older ones being not affected. The first symptoms of the disease appears as water-soaked greyish discolouration of the leaf tips, which spreads rapidly covering the whole leaf blade and the petiole. As the disease advances the leaf droops and within 24 to 48 hours it may involve the leaves, petiole, stem and the tender shoot and finally the whole plant may wilt. In the field patches of the wilted plants are seen distributed irregularly, but in the pots usually all the seedlings wilt within 48 hours after the apperance of the first symptoms. On the petiole and stem elongated dark brown lesions are found and on the leaves pycnidia of the fungus observed.

The pycnidia of the fungus are sub-epidermal, black, flask shaped, erumpent, ostiolate and measure 140 to 175 μ. The pycnidiospores are one celled, hyaline, thin walled, ellipsoidal or biguttulate, measuring

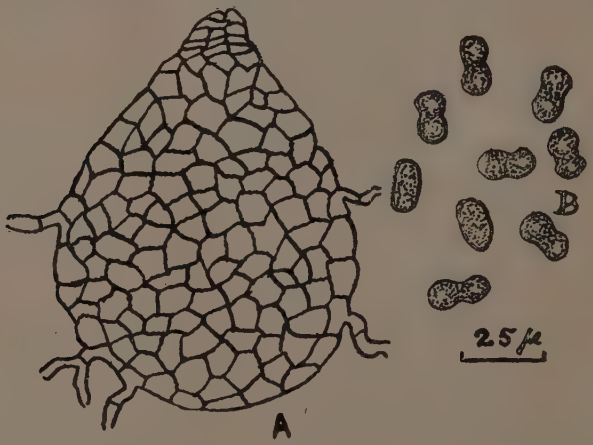

Fig. 1. (A) pycnidium and (B) pycnidiospores of *Phomopsis* sp. on *Phaseolus mungo* and *P. aureus*.

Fig. 2. Green gram: control (1) and inoculated with *Phomopsis* sp. (2) Black gram: control (3) and inoculated with *Phomopsis* sp. (4).

10.5 to 17.5 x 3.5 to 5.3 μ (Fig. 1). The fungus is readily brought into culture and it grows well on oatmeal, potato dextrose, nutrient and host-extract agar media. The fungus belongs to the genus *Phomopsis* but is different from *P. vexans* reported on brinjal (Pawar and Patel 1957)[1].

Pure culture of the fungus (*Phomopsis* sp.) were inoculated on the seedlings of black and green grams raised under controlled conditions. The mycelium together with the conidial mass was transferred to the washed leaf surface. On inoculation the plants were kept moist by periodical sprayings upto 24 hours. Though there was no disease incidence in the control plants, the fungus was found to cause severe blight of the seedlings within 48 hours (Fig. 2). The fungus could be easily reisolated from the diseased plants. When inoculated on the seedlings of various plants, the fungus was found to infect beans (*Dolichos lablab* L.) and radish (*Raphanus sativus* L.) causing localised spots on the leaves, but could not infect horse-gram (*D. biflorus* Roxb.), Bengal gram (*Cicer arietinum* L.), *Sesbania speciosa* L., *Crotalaria juncea* L., brinjal (*Solanum melongena* L.), tomato (*Lycopersicon esculentum* Mill), chillies (*Capsicum annuum* L.), bhendi (*Hibiscus esculentus* L.) and mesta (*H. cannabinus* L.).

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[1] Pawar, V. H. and Patel, M. K. (1957): Phomopsis blight and fruit-rot of brinjal. *Indian Phytopath.*, **10** : 115–120.

[2] Gosh, T. and Mukerji, N. (1958): Tip-rot of mesta (*Hibiscus cannabinus* L.) *Curr. Sci.*, **27** : 67–68.

A new powdery mildew disease of Carica papaya in India—B. L. Chona & Girdhari Lal. During a recent survey of plant diseases near about Delhi, a powdery mildew disease of *Carica papaya* plants caused by *Oidium caricae* Noack[1] was observed. This fungus has not, so far been recorded from India, although it is known to occur in several countries such as Java, Portugal, Bermuda, Hawaii, Uganda, Brazil, Cuba, East Africa and Venezuela.

The mildew develops as white, cottony, circular, appressed blotches, on the upper surface of the leaf. In severe infection the lower leaf surface is also involved. In the advanced stages of the disease, the major portion of the leaf surface gets covered with the mildew, and the infected leaves turn yellow and finally fall off leaving the plants almost leaf-less. The young tender leaves appear to be more susceptible.

The mycelium of the causal fungus is ectophytic, hyaline creeping, 4.5–7.0 μ in diameter, forming a thin coating on upper leaf surface; conidia are produced in chains of 2–4, and are hyaline, elliptic and measure 24–30 x 17–19 μ. *Oidium indicum* Kamat described earlier from India by Chiddarwar[2] on *Carica papaya* was compared with this fungus and found to be distinct in having barrel shaped and much larger conidia.

Our thanks are due to Dr. R. S. Vasudeva, Head of the Division of Mycology and Plant Pathology, and Joint Director, I.A.R.I., New Delhi, for helpful criticism and encouragement and providing the necessary facilities.

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[1] Noack, F. (1898): *Bolet. Instit. Agron.* do Estado de Sao paulo an Campanias **9** : 81.

[2] Chiddarwar, P. P. (1955): *Curr. Sci.* **24** : 239–240.

Simultaneous occurrence of Ustilago tritici **(Pers.) Rost., and Anguina tritici (S.)G. Ben. in a Single Ear of wheat**—Kishan Singh Bedi, Jaswant Singh Chohan & Devindar Singh Chahal. An interesting observation, not hitherto recorded in the Punjab, and perhaps also not elsewhere, was recorded during the month of March, 1959 in a wheat field in the Plant Pathological Area at the Government Agricultural College and Research Institute, Ludhiana. This was the presence of a solitary ear simultaneously infected with the fungus *Ustilago tritici*, causing loose smut and the nematode *Anguina tritici*, causing the earcockle disease, the remaining ears of the stool having been claimed by the latter pathogen. It was noticed that two-thirds of the ear constituting the lower part had been almost totally transformed into black sori of the loose smut fungus. The upper portion of this ear was infected by the earcockle nematode, the black galls of which were clearly visible from between the distended glumes.

There are cases on record, where two allied phyto-pathogenic fungi, for example, *Tilletia tritici* (Bjerk.) Wint. and *T. foetida* (Wallr). Liro, have been observed to occur in the same ear of wheat, and even in the same bunt ball, but the occurrence of two pathogens belonging to such widely separate taxonomic categories, i.e. one, a fungus, and the other, a nematode, is not only very interesting but also a rare phenomenon.

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Occurrence of stem galls of Physoderma limnanthemi Thirum. D. SURYANARAYNA—Thirumalachar (1949) described *Physoderma limnanthemi*, a chytridiaceous parasite on the leaves of *Limnanthemum indicum* Thw. collected from Bangalore, India. According to him, the pathogen produced hypophyllous galls measuring 2–8 mm. in diameter. Several of the galls bore on them adventitious roots. Recently, the writer examined some galls caused by this fungus on the stems of *Limnanthemum indicum* collected

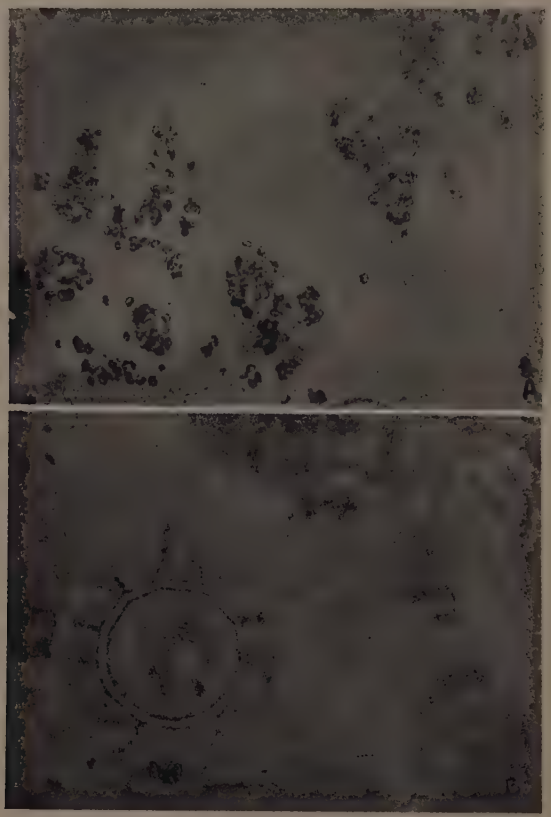

Plate 1

A. A portion of the gall showing spores in sori. x 60

B. Two spores enlarged. One in the centre cut medianly showing spines on the surface. The other in the right hand top corner showing concave depression on one side. x 960

in 1952 from Ajmer by B. D. Tiagi. The galls are larger (6–14 mm.) in diameter and bore no adventitious roots at all. Sections were cut to study the structure of the gall. It was found that some of the cells of the compact zone of the primary cortex divide into a gall. The inner side of the gall enlarges considerably and pushes itself into the lacunar part of the cortex. The gall included a few cortical vascular bundles. Microtome sections of the gall were cut and stained with safranine and fast green. Only the resting spore stage of the parasite could be noticed. Aggregates of spores were found in round or oval sori formed in cavities within the gall (Plate I A, B,). This is the first time this pathogen was collected in North India.

Division of Mycology,
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THIRUMALACHAR, M. J. (1949): A Chytridiaceous parasite of *Limnanthemum indicum*. *Ind. Phytopath.* **2** (2): 128-131

INSECTICIDES AND PESTICIDES FOR AGRICULTURAL PURPOSES

(Four Indian Standards Published)

The following four Indian Standard Specifications published recently by ISI prescribe requirements and methods of test for the material covered by each:

(1) **Specification for 2, 4-D-Sodium (IS: 1488-1959):** The monohydrate sodium salt of 2, 4-Dichlorophenoxyacetic acid, namely 2, 4-D-Sodium is extensively used in the control of weeds in agricultural cereal crops, gardens, lawns, etc. The prescribed requirements relate to physical description, loss on drying, acid content, equivalent weight and melting point of the acid.

(2) **Specification for BHC Smoke Generators (IS : 1505-1959):** BHC smoke generators present a convenient form for the use of the insecticide in the agricultural and public health fields. In the agricultural field, the generators are used for disinfecting warehouses for the storage of grains, flour, tobacco, etc., against weevils, beetles, etc. and, in the public health field, they are used for disinfecting buildings against fleas, cockroaches, flies, mosquitoes and moths. Besides the physical description, the other requirements prescribed for the material cover gamma isomer content and smoke forming property.

(3) **Specification for Copper Oxychloride Dusting Power (IS :1506-1959 and Specification for Copper Oxychloride Water Dispersible Powder Concentrates (IS : 1507-1959):** Copper oxychloride dusting powders and copper oxychloride water dispersible powder concentrates containing varying percentages of copper oxychloride, technical are largely used as fungicides for the control of plant diseases in agriculture and horticulture. The two standards lay down the physical requirements, such as description, colour and particle size of the material, and chemical requirements, such as copper contents, total soluble alkali, etc., for their respective materials.

The standards are published in English. IS : 1488-1959 and IS: 1507–1959 are priced at Rs 2.00 each while IS :1505-1959 and IS-1506 1959 are priced at Rs 3.00 and 2.50 respectively. Copies are available from the office of the Indian Standards Institution, 'Manak Bhavan', 9 Mathura Road, New Delhi-1 and from its Branch Offices located at Bombay, Calcutta and Madras.

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